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Investigations into the "Stalling" of Subterranean Clover in the Lower Rainfall Pasture Belt of Western Australia.

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SUMMARY.

WITH the usual method of management, a uniform stand of even the early (Dwalganup) strain of subterranean clover cannot always be maintained in the lighter rainfall clover belt of Western Australia. After a varying period following establishment, mainly four or five years, grasses and weeds become more plentiful to the detriment of the clover content and often erodium* and cape weed† develop to such an extent that few clover plants can be found. This condition is known as a "stalled" pasture.

The belt of country concerned has an average annual rainfall of 20 inches or somewhat less, approximately 60 per cent. of which falls during May-August, the four wettest months. The four driest months, November-February, seldom contribute more than 10 per cent. and the rainfall of the remaining four months is unreliable. An appreciable range in temperature is also experienced. At Katanning the average maximum for January, the hottest month, is 86.2° while the corresponding figure for July, the coldest month, is 57.9°. The average minima for these two months are 55.9° and 41.5° respectively.

Early reports indicated that the problem was characteristic of wandoo‡ country, but although most of the stalling occurs where this tree is dominant, it is also experienced beyond the range of the wandoo.

The programme of investigations commenced in 1941 and supplemented in subsequent years in the light of information secured, was directed along the following main lines:—

1. To record the plant succession and trace the stage of diminution of subterranean clover growth.
2. To detect any soil variation which may be linked with the reduction in the stand of clover.
3. To establish and maintain clover on stalled land.
4. To ascertain the effect of the establishment of pasture grasses and various cultural treatments on the maintenance of a clover pasture.

* Erodium botrys (Cav.) Bertol.
† Cryptostemma calendulaceum (L.) R.Br.
‡ Eucalyptus redunca Schau. var elata Benth.

The work undertaken showed that the stalling of subterranean clover in the Great Southern District cannot be attributed to any single factor. It was concluded, however, that there are two dominant influences, firstly climate, especially period of rainfall, and secondly the effect of the clover and associated phosphate dressings on the soil.

Although temperature and the nature of the spring rains have a bearing on the problem, the periodicity of rains at the commencement of the season represents the major climatic factor. If falls sufficient to induce germination are followed by a long dry period, severe malting of the clover seedlings takes place, thus paving the way for dominance by the more drought resistant weed species.

Closely linked with the climatic factor is the effect of the clover growth and associated phosphate dressings on the nitrogen content of the soil, and in consequence the botanical composition of the pasture, favouring the non-leguminous weeds to the detriment of the clover. The plant population is also increased, resulting in heavier demands on the available soil moisture. When this weed phase is reached the climatic factor assumes maximum proportions and the balance inclined in favour of the weeds can be tilted completely by adverse moisture conditions, especially in the autumn.

Other factors are also concerned to a greater or lesser extent. Insects, especially red mite‡ and lucerne flea§ can play their part in reducing a stand of clover. There is also evidence of deterioration due to a deficiency of copper and possibly magnesium, but such cases are not general.

Experimental work and the experience of some farmers have shown that pastures tending to deteriorate can be revitalised by cropping. In most cases deep ploughing is inadvisable and satisfactory results have been achieved by making a dry, shallow sowing of oats, preferably with Wimmera rye grass.

The value of introducing a perennial grass has been demonstrated on small areas, but difficulty has been experienced in establishing and maintaining even the more hardy perennial species such as perennial veldt grass‖ and Phalaris tuberosa¶. The most satisfactory grass species under trial proved to be Wimmera rye grass**.

INTRODUCTION.

Although extensive areas in the Great Southern district are now under subterranean clover††, the development of pastures in this region has occurred mainly during the last twenty years with the maximum rate of progress during the last decade. Most of the initial efforts were made with the midseason or Mt. Barker strain which caused many disappointments when it failed to persist where the rainfall approximates 20 inches per annum and the growing season is also short. These unfortunate experiences caused many farmers to discount the possibilities of growing subterranean clover on their properties and did much to retard the establishment of the Dwalganup strain, which, with its earlier maturing habit, is much more suited to the conditions. This strain now covers many thousands of acres and represents the dominant component of improved pastures in the lighter rainfall areas. It was soon noted, especially in the Great Southern, however, that with the normal method of management, a uniform stand of clover could not always be maintained and after a

‡ Halotydeus destructor. § Smynthurus viridis. ‖ Ehrharta calycina Sm.
¶ Phalaris tuberosa L. ** Lolium subulatum Vis. †† Trifolium subterranean L.

varying period following establishment, usually four or five years, grasses and weeds became more plentiful to the detriment of the clover content. Erodium (wild geranium)* and cape weed† proved to be the most troublesome intruders and in many pastures developed to such an extent that few clover plants could be found. This condition is known as a "stalled" pasture.

In 1937 a committee was formed consisting of Mr G. K. Baron Hay, Dr. L. J. H. Teakle and Mr. I. Thomas, later to be joined by Mr. M. Cullity, to initiate investigations in an endeavour to find means of preventing or correcting this deterioration of the clover stand. Experiments with which Messrs. A. S. Wild and H. G. Elliott were also closely associated were commenced in 1938. These were designed to explore the many possible causes, suggested by both farmers and technical officers. The behaviour of pastures indicated the deficiency of some minor element and the possibility of the continued use of superphosphate depleting or rendering unavailable some element such as zinc, copper or manganese could not be overlooked. A number of both field and plot trials were carried out using different combinations of these and other minor elements but no definite response was obtained. In addition various mixtures and rates of application of superphosphate, sulphate of ammonia, potash and lime were tried but the only indication of a benefit due to fertilizer application, other than superphosphate, under field conditions, was obtained with potash which in some cases was slightly beneficial.

Various systems of management involving cultivation and the sowing of Wimmera rye grass were also investigated but although a great deal of detailed information was obtained during the years 1938-40, which allowed certain factors to be eliminated when considering this problem, the committee concluded that no definite evidence that would be of major importance in overcoming the stalling of clover had been obtained.

At this stage it was decided that a special detailed investigation should be commenced. The writer was requested to undertake this investigation in collaboration with Mr. A. S. Wild. During 1941 an opportunity was taken to become thoroughly acquainted with the nature and extent of the problem but in the following year, Mr. Wild was unable to continue his association with the work and my own efforts were appreciably curtailed in this and subsequent years owing to difficulties created by the war. It is felt, however, that a deal of light has been thrown on the problem as outlined in the following pages.

SURVEY.

In the course of the preliminary survey it was ascertained that stalling of subterranean clover has been experienced over an extensive area in the Great Southern District but, in the main is confined to that zone east of the 20 inch isohyet. Similar stalling occurs in the comparable rainfall belt further north but the Great Southern is selected for particular reference as most of the observations were made and experimental work carried out in that district.

Climate.

This belt of country, typically represented by such centres as Narrogin, Wagin, Katanning and Cranbrook, has an average annual rainfall of 20 inches or somewhat less, approximately 60 per cent. of which falls during May—August, the four wettest months. The four driest months, November—February, seldom contribute much more than 10 per cent. and the rainfall of the remaining four months cannot be regarded as reliable, although May—October are normally the six wettest months. Variation from the mean relative to both total rainfall and time of fall is often very marked as shown by

* Erodium botrys (Cav.) Bertol. † Cryptostemma Calendulaceum (L.) R.Br.

Table 1, and extremes represented by drought conditions and excessive rainfall have occurred in recent years.

TABLE 1.—RAINFALL.

Centre.	Annual.	Wet Season, May-Aug.	Percentages of Annual.	Dry Season, Nov.-Feb.	Annual Variation.
	points.	points.	%	points.	%
Beverley	1688	1127	67	148	20
Narrogin	2015	1269	63	196	14
Wagin	1756	1064	60	177	17
Katanning	1873	1089	58	222	17
Cranbrook	1998	1093	55	276	15

Map showing isohyets and months of influential rainfall (broken lines).

The Annual variation column represents the average percentage departure from the mean. (Figures after Gardner and Gentilli).

An appreciable range in temperature is also experienced. At Katanning the average maximum for January, the hottest month, is 86.2° while the corresponding figure for July, the coldest month, is 57.9°. The average minima for these two months are 55.9° and 41.5° respectively, while the extreme recordings over a period of 44 years have been 112.3° and 25.0°. The monthly mean relative humidity is 70% at 9 a.m. and 51% at 3 p.m., the 9 a.m. figure ranging from 87% in July to 55% in December and January. The corresponding saturation deficit figures are .171 and .378, the extreme 9 a.m. range (July-January) being .045-.324.

Although other factors such as temperature and length of day must be taken into account, the range of a particular species is governed to a large extent by the period of moisture availability. This in itself is dependent on a number of factors predominant among which are the total rainfall, the period during which it falls and the evaporation. Trumble (7, 8) has defined the "period of influential rainfall" as the time interval over which the surface soil (0-4in.) tended to be maintained above the wilting point for herbage plants. This was found to be equivalent to the period over which rainfall exceeded approximately one-third of the monthly evaporation from a free water surface. In the absence of sufficient evaporimeter records, values for the mean monthly saturation deficiency were found satisfactory for the determination of evaporation.

Basing his findings on observations in South Australia, Trumble states that it appears perfectly safe to mark the limits of the midseason strain by the 7.5 month line. Also that the earlier maturing strain (Dwalganup) has been grown successfully over a period of five years, at centres with mean values of 6.5 to 7.5 months and can probably be adopted as an improved pasture species at least to the 6.5 months line, and possibly to the 6.0 months line. The 6.0 and 7.5 lines as prepared by Trumble are marked on the appended rainfall map but do not conform closely to the practical limits of the two strains in this State, erring in the direction of exceeding the present recognised range for reasonably "safe" pastures.

Vegetation.

Earlier reports suggested that the problem was characteristic of wandoo country, but this was not found to be entirely correct. Wandoo (*Eucalyptus redunca* var. *elata*) occurs over an extensive area and varies in its associations. It is represented at its western limits by scattered trees in the jarrah forest of the Darling Range where clover stalling is not a problem. Further east, with decreasing rainfall, the wandoo becomes the dominant tree, being mainly associated with York gum (*E. foecunda* var. *loxophleba*) and jam (*Acacia acuminata*) forming open savannah-like country with low shrubby or herbaceous undergrowth. The proportion of the three major components varies considerably, the York gum and jam gradually displacing the wandoo in a northerly direction until its limits are reached at Arrino. To the south, in the vicinity of Wagin, the character of the woodland undergoes a change, the swamp yate (*E. occidentalis*) becoming of significance, especially on clay depressions, and the wandoo tending to be restricted to the light sandy soils. Further south in the Cranbrook area the wandoo ceases to be of importance and the yate (*E. cornuta*) and swamp yate dominate the woodland. Again the region under review contains appreciable

areas of mallet (*E. astringens* and *E. Gardneri*) which occur typically on lateritic formations. Although it can be said, therefore, that most of the stalling difficulties are encountered on wandoo country, all such country is not dominated by that tree and stalling also occurs in such districts as Cranbrook where the wandoo is of little significance.

Much of the stalling occurs on jam, wandoo and sheoak country depicted above.
(Photo: R. C. Rossiter.)

Soils.

With the exception of the laterite or gravel the soils are predominantly sandy or of a loamy sand varying from grey to dark brown in colour and usually of a gritty nature. Somewhat heavier soils of a finer texture are encountered on flats as the result of deposits from flood waters. There is considerable variation in the depth of the soil and at time an impervious clay layer occurs close to the surface.

Much of the laterite country immediately east of the 20 inch isohyet being of a hilly nature and difficult to work has not found favour for the establishment of subterranean clover, especially as it is being utilised for mallet re-afforestation. In consequence our experiences have been mainly with gritty sands or sandy loams which comprise the major soil type of the area.

Often a physical factor such as an impervious clay layer close to the surface has been a considerable local influence by virtue of its effect on the moisture content of the soil. Although providing useful information, such examples have little influence on the problem when considered in its entirety.

Strain of Clover.

The deterioration is commonplace among pastures established with the mid-season (Mt. Barker) strain but large areas of the early (Dwalganup) strain are also affected. The major intruders associated with the diminution of the

clover content are erodium, cape weed, and annual grasses including barley§§, brome‖‖, and silver grass¶¶. Wild geranium is of most significance in this respect often growing to the exclusion of practically all other species on large areas of previously good subterranean clover pastures.

Stalling of subterranean clover of a somewhat different nature has occurred on certain soil types on the south coast and also in the vicinity of Busselton, but this is related to a copper and possibly manganese deficiency and does not come within the scope of this report.

EXPERIMENTS.

The programme of work commenced in 1941 and supplemented in subsequent years in the light of information secured, was directed along the following main lines:—

1. To record the plant succession and trace the stages of diminution of subterranean clover growth.
2. To detect any soil variation which may be linked with the reduction in the stand of clover.
3. To establish and maintain clover on stalled land.
4. To ascertain the effect of the establishment of pasture grasses and various cultural treatments on the maintenance of a clover pasture.

Plant Succession.

General observations left no doubt that good stands of clover could deteriorate until the proportion of clover became negligible, but at the commencement of this investigation no information was available as to when, within the season, the diminution in the stand could be expected to occur. Was it due to poor germination, a satisfactory germination followed by seedling destruction or failure of the plants to reach reproductive maturity resulting in no seeding down for the following season? As the answers to these questions are of fundamental importance, it was decided, by making plant counts and seed estimations, to trace the history of the clover from the time of the initial sowing.

By including weed counts it was also proposed to secure a picture of variation in the species content as the pasture developed. For this purpose, fertiliser demonstration plots established in conjunction with the Cuming Smith Mt. Lyell, Farmers Fertilisers Ltd. at Yornaning, Wagin and Kojonup were utilised. Each of these consisted of five, one fifth acre plots, treated as follows:—

1. Sown with 8 lb. of early (Dwalganup) subterranean clover seed and topdressed each year with 60 lb. of superphosphate per acre.
2. Sown with 8lb. of early (Dwalganup) subterranean clover seed and topdressed each year with 180 lb. of superphosphate per acre.
3. Natural pasture without fertilizer.
4. Sown with 8lb. of early (Dwalganup) subterranean clover seed and topdressed each year with 120 lb. of superphosphate per acre.
5. Natural pasture topdressed each year with 120 lb. of superphosphate per acre.

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§§ Hordeum murinum L. and H. maritimum With.

‖‖ Bromus madritensis L., B. rubens L., B. Gussonii Parl., Serrafalcus hordeaceus (L.) Green et Godr. and S. molliformis F. Schultz.

¶¶ Vulpia myuros (L.) Gmel. and V. bromoides (L.) S. F. Gray.

An early subterranean clover pasture in the foreground. The sheep are grazing on oats, Wimmera rye grass and clover.
(Photo: R. C. Rossiter.)

Unfortunately these plots were not replicated at each site but observations over a period of five years have given a complete history of seasonal plant population, both weeds and clover, along with the amount of clover seed present in the soil at the beginning of the growing season. This latter figure represents the seeds produced during the preceding year together with an accumulation of hard seeds from previous seasons.

It was derived by taking five one-square-link samples from each plot to a depth sufficient to remove all the burrs—approximately two inches. The burrs from each spit were then separated, counted and weighed and an estimation of the seed content made by counting and weighing the seed removed by hand from triplicated one gram samples of burr, taken from each bulk plot sample. These seeds were then used for germination tests.

Seed figures are included in Table 2 and represented graphically in Graphs 1—3.

It is impossible to generalise concerning the three series of plots apart from stating that moisture during the five years since establishment has been the predominant factor in deciding the growth and botanical composition. Each series has reacted less to the total rainfall than to the period during which it fell and local conditions regarding retention of moisture in the soil have played a very important part, on occasions more than offsetting the difference in fertilizer application. In this respect the plots have shown very clearly the necessity for replications when comparisons between different treatments are to be made. They were designed originally as demonstration plots, however, and have served a very useful purpose in these investigations.

TABLE 2.

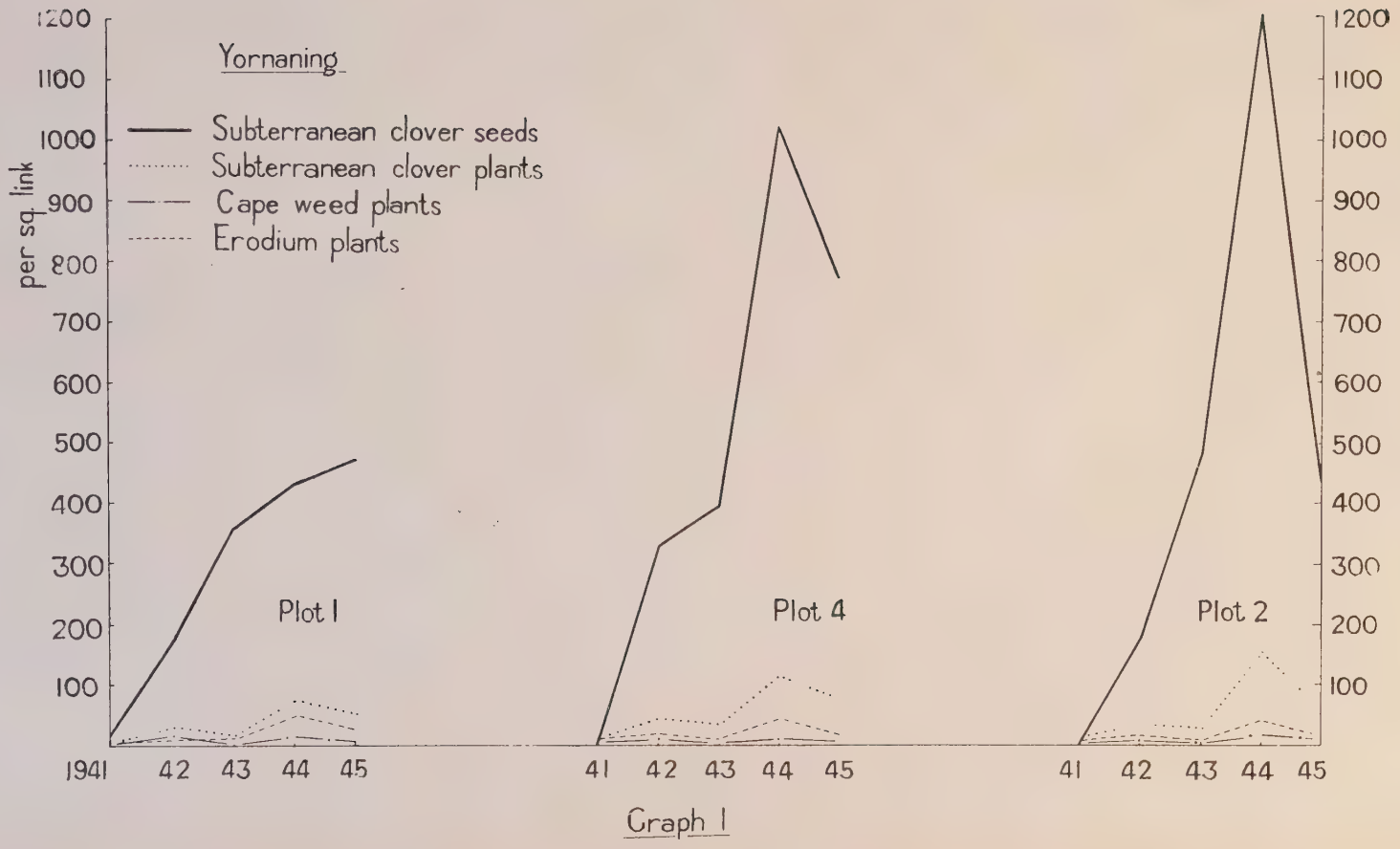
SEED ESTIMATIONS.

	Plot 1.				Plot 4.				Plot 2.			
	1942.	1943.	1944.	1945.	1942.	1943.	1944.	1945.	1942.	1943.	1944.	1945.
YORNANING.												
Weight of burrs per sq. link—grams	2·7	5·3	7·4	7·8	5·2	6·7	15·6	15·3	2·5	7·8	17·1	10·7
Number of burrs per gram	18	33	42	44	19	28	33	36	19	28	30	42
Number of seeds per gram of burr ...	60	53	58	61	63	48	66	51	67	51	71	44
Number of seeds per sq. link ...	164	271	429	473	330	322	1030	779	169	401	1216	470
Weight of seeds per gram of burr ...	0·39	0·27	0·29	0·28	0·42	0·29	0·37	0·31	0·42	0·29	0·39	0·26
Weight of one seed—gram	·006	·005	·005	·005	·007	·006	·006	·006	·006	·006	·005	·006
Equivalent lbs. per acre	232	315	472	481	481	428	1271	1044	231	498	1469	612
WAGIN.												
Weight of burrs per sq. link—grams	0·9	4·2	8·8	5·8	0·4	1·8	4·6	4·0	0·7	1·1	6·1	4·0
Number of burrs per gram	21	26	26	37	32	36	30	45	22	30	27	39
Number of seeds per gram of burr ...	72	48	67	41	92	58	85	45	73	30	73	45
Number of seeds per sq. link ...	63	202	590	237	40	104	391	181	53	33	445	179
Weight of seeds per gram of burr ...	0·42	0·36	0·44	0·25	0·48	0·35	0·49	0·27	0·42	0·22	0·50	0·32
Weight of one seed—gram	·006	·007	·007	·006	·005	·006	·006	·006	·006	·007	·007	·007
Equivalent lbs. per acre	83	333	853	319	42	138	496	237	64	53	672	282
KOJONUP.												
Weight of burrs per sq. link—grams	1·4	0·8	1·3	3·8	2·1	3·8	12·2	8·2	2·0	0·8	2·6	4·0
Number of burrs per gram	21	32	20	34	25	32	28	37	22	27	21	33
Number of seeds per gram of burr ...	69	37	61	77	74	53	72	73	70	49	60	75
Number of seeds per sq. link ...	100	30	79	296	153	201	878	599	143	39	156	302
Weight of seeds per gram of burr ...	0·51	0·25	0·48	0·46	0·50	0·32	0·47	0·41	0·48	0·42	0·45	0·43
Weight of one seed—gram	·007	·007	·008	·006	·007	·006	·007	·006	·007	·009	·008	·006
Equivalent lbs. per acre	157	44	137	385	231	267	1264	740	211	74	257	379

The total rainfall and the time at which it has fallen have proved such significant factors that it has been considered advisable to give some visual representation of each season. Although a complete block graph for the entire year proves a little unwieldy it represents the most satisfactory method of depicting wet and dry periods along with the amount of each fall. Graphs have been prepared for Narrogin, Wagin, and Kojonup (see pages 119-123). In each case the experimental site is some few miles distant from where the record was taken but the figures give a good impression of conditions at the plots. The Yornaning site is twelve miles north of Narrogin.

(a) *Yornaning.*—A dense stand of erodium and cape weed was ploughed in on 28th April, 1941, and, following harrowing, the plots were sown by hand. Although a proportion of the erodium recovered, a good first-year stand of clover developed under favourable seasonal conditions. The following season, although there was a quantity of erodium and annual grasses (mainly silver grass) present, these plants were largely obscured by a comparatively dense stand of clover which formed practically a complete ground cover on all sown plots. The erodium plants were small and unthrifty, a condition attributable to the cold winter which retards weed species such as cape weed and erodium to a much greater extent than the clover. Similar observations have been made by Cook (2) in South Australia. 1943 was a year of early opening rains but unfortunately, heavy falls at the beginning and middle of February, were not supplemented until 7th March and a further dry period was experienced between 17th April and 14th May. Although this caused a considerable loss of clover seedlings, a satisfactory stand resulted from those that persisted along with others resulting from subsequent germination. It was noticeable, however, that badly withered clover seedlings made very slow recovery. On the 120 lb. super. plots the erodium was more vigorous when associated with clover than as a component of natural pasture, thus reflecting an improvement in the soil—probably a higher nitrogen level—in the third season under clover. Good September and October rains were conducive to heavy seed setting as shown by the 1944 peaks in Graph 1. As this represents the seed in the ground at the beginning of that year, it is actually a measure of the 1943 crop along with residual hard seeds from previous seedings.

1944 was a reversal of the previous year. Good early rains produced a dense mass of seedlings, especially on the plots with the lighter super. dressings, but lack of finishing rains reacted unfavourably against seed production. It is interesting to note the seed yield trends in Graph 1, paying particular attention to 1945 which, as already mentioned, is really a measure of the previous year. Although the figure for plot 1 (60 lb. super. per acre) is not as high as that for plot 4 (120 lb. super. per acre) and equals 2 (180 lb. of super. per acre) it represents an increase on the previous year and not a decline as in the other two cases. It is impossible for the seed yield to be stepped up each year but the higher super. dressings have brought the plots to their maximum more rapidly. This is not a fixed maximum, however, and if more favourable conditions had pertained during September and October an increase may have been maintained, but under the low moisture conditions prevailing, some 67 plants per sq. link on plot 1 produced more seeds than 146 per sq. link on plot 2. The final seed yields were approximately the same but hard seeds from previous seedlings would account for more of the plot 2 total.


Yornaning
Subterranean clover seeds
Subterranean clover plants
Cape weed plants
Erodium plants
per sq. link
1200
1100
1000
900
800
700
600
500
400
300
200
100
Plot 1
Plot 4
Plot 2
1941 42 43 44 45
41 42 43 44 45
41 42 43 44 45

Graph 1

TABLE 3.

PLANT COUNTS.

Plot.	Species.	1941.	1942.	1943.	1944.	1945.
Yornaning 1.	Subterranean clover seeds ...	5·4	164	*354	429	473
	Subterranean clover plants ...	2·1	29	20	67	51
	Erodium plants	3·4	11	11	45	26
	Capeweed plants	1·0	12	2	10	6
Yornaning 2.	Subterranean clover seeds ...	5·4	169	*489	1216	470
	Subterranean clover plants ...	2·1	27	21	146	52
	Erodium plants	3·6	11	5	39	12
	Capeweed plants	2·1	6	2	9	2
Yornaning 3.	Subterranean clover seeds ...	...	...	...	...	...
	Subterranean clover plants ...	...	...	...	...	...
	Erodium plants	3·6	21	16	...	...
	Capeweed plants	1·2	22	3	...	...
Yornaning 4.	Subterranean clover seeds ...	5·4	330	*398	1030	779
	Subterranean clover plants ...	3·0	41	30	108	73
	Erodium plants	3·6	14	5	41	150
	Capeweed plants	1·6	7	2	6	4
Yornaning 5.	Subterranean clover seeds ...	...	...	...	...	...
	Subterranean clover plants ...	...	...	...	...	...
	Erodium plants	7·2	26	19	...	...
	Capeweed plants	1·0	17	1	...	...
Wagin 1. ...	Subterranean clover seeds ...	5·4	63	*213	590	237
	Subterranean clover plants ...	1·8	7·0	10	271	51
	Erodium plants	0·6	3·2	2·3	24	4
	Capeweed plants	2·3	16	8	32	26
Wagin 2. ...	Subterranean clover seeds ...	5·4	53	*39	445	179
	Subterranean clover plants ...	1·3	4·1	9	207	18
	Erodium plants	0·3	2·1	2·0	20	6
	Capeweed plants	2·4	25	6	51	13
Wagin 3. ...	Subterranean clover seeds ...	...	...	...	...	...
	Subterranean clover plants ...	...	...	...	...	...
	Erodium plants	0·3	0·5	...	...	...
	Capeweed plants	3·8	43	...	...	...
Wagin 4. ...	Subterranean clover seeds ...	5·4	40	*111	391	181
	Subterranean clover plants ...	2·0	7·2	14	198	27
	Erodium plants	0·1	0·9	1·4	4	4
	Capeweed plants	4·6	27	6	56	26
Wagin 5. ...	Subterranean clover seeds ...	...	...	...	...	...
	Subterranean clover plants ...	...	...	...	...	...
	Erodium plants	0·2	0·8	...	...	...
	Capeweed plants	1·8	27	...	...	...
Kojonup 1. ...	Subterranean clover seeds ...	5·4	100	*31	79	296
	Subterranean clover plants ...	2·2	0·1	3·1	40	15
	Erodium plants	2·5	49	11	73	16
	Capeweed plants	0·1	0·2	0·8	0·6	0·1
Kojonup 2. ...	Subterranean clover seeds ...	5·4	143	*41	156	302
	Subterranean clover plants ...	1·5	...	1·2	57	8
	Erodium plants	2·1	51	4	120	8
	Capeweed plants	0·1	...	0·8	0·6	0·4

Plot.	Species.	1941.	1942.	1943.	1944.	1945.
Kojonup 3. ...	Subterranean clover seeds ...	...	...	...	...	...
	Subterranean clover plants ...	...	...	...	...	...
	Erodium plants	1·8	52	8	...	...
	Capeweed plants	0·1	...	2·3	...	...
Kojonup 4. ...	Subterranean clover seeds ...	5·4	153	*207	878	599
	Subterranean clover plants ...	2·1	2·8	7·0	140	51
	Erodium plants	3·0	51	7	58	18
	Capeweed plants	0·5	1·1	1·9	3·3	2·6
Kojonup 5. ...	Subterranean clover seeds ...	...	...	...	...	...
	Subterranean clover plants ...	...	...	...	...	...
	Erodium plants	3·0	52	11	...	...
	Capeweed plants	2·0	21·7	6·2	...	...

* Partly computed figure due to summer germination prior to sampling.

The large clover population made competition keen for the very limited supply of moisture available at the end of the season and the competitive aspect was accentuated, especially on the plots with the higher super. dressings, by the highest erodium content experienced to this stage, equivalent to some 40 plants per square link. Annual grasses, especially silver grass were more conspicuous than previously, being most apparent on plot 2, receiving the largest super. application.

A satisfactory germination, although less than that of 1944, took place in 1945, but the excessive rainfall caused the experimental site to be waterlogged for extended periods. When inspected in September the clover was very backward on all plots and the erodium had also been affected adversely. The clover present earlier in the season had disappeared entirely from sections, particularly on plot 1 which was submerged for the longest period. The presence of a small sedge in quantity was indicative of the conditions.

(b) *Wagin.*—Following necessary workings the plots were sown by hand on 30th May, 1941. Seedling establishment was somewhat less than at Yornaning but the difference did not account for the much lower seed yield. As shown by Table 2, the reduction was due, not to fewer seeds per burr, but to the formation of fewer burrs. There was a moderate stand of clover in 1942 reflecting the comparatively poor seed setting of the previous year and the soil seed supply was to a certain extent rectified. The unseasonal rains early in 1943, however, gave the pasture a further setback as many clover seedlings "malted" during the dry period following substantial March rains. The season ended favourably, however, and a satisfactory seed setting followed by an ideal growing season in 1944 resulted in a good stand of clover on all plots. That year did not end as well as it began, however, and due to the absence of spring rains, seed setting was light. Although less than at the commencement of 1944 there was sufficient immediately viable seed in the soil to produce a complete sward of excellent clover in 1945.

Wagin
Subterranean clover seed
Subterranean clover plants
Cape weed plants
Erodium plants
lbs per sq link
600
500
400
300
200
100
Plot 1
Plot 4
Plot 2
1941 42 43 44 45
41 42 43 44 45
41 42 43 44 45

Graph 2.

The acute 1944 peaks in the clover seedling "curve" of Graph 2 can be attributed to a heavy seed setting in 1943, followed by a favourable growing season in 1944, originating the sharp upward slope and the dry spring of 1944 with associated low seed yield, contributing to the downward slope.

At no time has erodium been prominent on these plots but cape weed has been conspicuous, the number of plants showing a seasonal variation similar to that of the clover with a tendency to increase in 1945. Annual grasses have been of little consequence but clovers such as hop***, suckling†††, and woolly‡‡‡, have been plentiful in sections not dominated by the subterranean clover.

Although the curves for the individual species are similar for the three plots, they cannot be correlated with the rate of super. application. This is undoubtedly due to the fact that plot 1 is in a favoured position relative to moisture. Besides being on the lower level of a slope, there is clay near the surface and the plot obviously retains moisture longer than the remainder of the experimental site. This has been conducive to larger seed and seedling production but observations indicate that greater forage yields would be obtained from the plots receiving heavier phosphate dressings.

When an inspection was made on 22nd September, 1944, during a very dry spring, there was ample evidence to show that the density of the plant sward has an appreciable bearing on the effect of adverse climatic conditions. Where the sward was comparatively sparse the clover plants were still green and had a much better chance of seeding down than where the clover or clover plus weed content was dense. These observations support the figures already quoted for the Yornaning plots.

(c) *Kojonup.*—From one angle these plots proved disappointing but from another most enlightening. The plots, which prior to cultivation carried an abundant weed growth, were sown by hand on 2nd May, 1941. Vigorous plants resulted from a satisfactory germination, the other vegetation consisting of a strong growth of erodium, cape weed and minor annual clovers along with some grasses. Seed setting was good and provided the foundation for an excellent second year stand. This was not to be however, as heavy March rains induced a profuse germination, only for the majority of the seedlings to be killed by the subsequent dry period. The rainfall chart for Kojonup (see page 122) gives an indication of the autumn experienced but the registrations at the experimental site show an even greater isolation of the March fall. They were as follows:—

13th March	73 points
14th March	58 points
19th March	35 points
20th April	60 points

The 166 points was sufficient to germinate the clover along with the various weeds, but although many of the weeds, especially the erodium, survived the hot, dry month until the next fall on 20th April, the clover plants that persisted were limited to a few favoured sections relative to soil moisture.

When the plots were inspected on 30th April, few subterranean clover plants could be found except on a moist section of plot 4 and the site was dominated by a dense growth of erodium. There was evidence on other parts of the property to show that a greater survival of clover was experienced where weed competition was less. Subsequent inspections did not reveal an

*** Trifolium procumbens L. ††† T. dubium Sibth. ‡‡‡ T. tomentosum L.

Kojonup
Subterranean clover seeds
Subterranean clover plants
Cape weed plants
Erodium plants
per sq ft
900
800
700
600
500
400
300
200
100
Plot 1
Plot 4
Plot 2
1941 42 43 44 45
41 42 43 44 45
41 42 43 44 45

Graph 3

improvement in the clover content of the original plots but there was a satisfactory growth on cross strips sown at the time of the April rains. This would appear to eliminate all but the climate when considering factors responsible for this example of stalling.

Those interested in this site from a pasture demonstration viewpoint wished to renovate and resow the area but in order to ascertain the capacity of the subterranean clover to recover, no treatment was given apart from the annual superphosphate application. A rapid recovery could not be expected for, with the exception of plot 4, little or no seed formation took place in 1942 and the 1943 growth was dependent on hard seeds resulting from the 1941 seed setting, i.e. the year of establishment. Unfortunately further "malting" occurred at the beginning of 1943 but scattered plants persisted on plots 1 and 2 and there was a comparatively good stand on the naturally moist plot 4. By the spring of 1944 the plots showed a marked recovery and although the clover was not dense it was healthy and competing successfully with a quantity of erodium, sorrel, and annual grasses. The cross-strips previously mentioned carried a comparatively dense stand of healthy subterranean clover up to 1ft. high.

The relatively high seed content of the soil at the beginning of 1945 indicated the possibility of an even better pasture during that year. This eventuated in the case of the cross-strips which produced an excellent stand of clover. The growth on the main plots was fair but although there was a considerable reduction in the erodium development, annual grasses were more conspicuous. It was noted that very few plants, either clover or erodium, occurred among matted brome grass§§§ resulting from the previous year's growth. This same observation had been made in other pastures where surface trash was allowed to accumulate. Such should be avoided by grazing or renovation.

As in the case of the Wagin series the variation in the moisture content of the plots more than counterbalanced any fertilizer effect as far as plant numbers were concerned and although the soil seed content of plot 4 reached a peak in 1944, plots 1 and 2 with their fewer number of plants, showed a further increase in 1945.

Observations.—Although there was only a comparatively small variation between the number of subterranean clover plants on all sown plots of the three series in the season of establishment, the following year disclosed an entirely different picture. The plants at Yornaning had increased to the extent of over 1000 per cent. while at Wagin there was an increase of somewhat more than 200 per cent. and at Kojonup a decrease of nearly 100 per cent.

The primary factors deciding the number of seedlings produced are the total number of subterranean clover seeds present in the soil linked with their immediate germinating capacity. As the plots were sown in 1941 the seed estimations made early in 1942 actually recorded the seed production during the previous year. Despite the same rate of sowing (8 lb. per acre) the seed yields at Yornaning and Kojonup were considerably in excess of Wagin. On the other hand the relationships between estimated seedlings and actual seedling establishment in 1942 were comparable at Yornaning and Wagin but Kojonup showed extreme disparity. Even with the comparable figures

§§§Serrafalcus hordeaceus (L.) Green et Godr.

the difference between the estimated and actual seedlings represents a wastage of approximately 70 per cent. I am unable to locate information of this nature resulting from previous work but this would appear to be a normal figure to expect in the early stages of a pasture.

The apparently heavy loss of seedlings may be attributed in part to the fact that burrs are not always in a position favourable for the germination of the enclosed seed. If the burrs are on the surface the possibility of malting is increased. Again, seedlings originating from seeds in a single burr are necessarily closely grouped thus stepping up the risk of loss due to competition. Even given optimum conditions following heavy seed setting of an established pasture there is a limit to the number of seedlings per unit of area that will survive. Apart from the physiological aspects, consideration must also be given to the depredation of insects, especially red mite and lucerne flea, which are capable of great destruction among clover seedlings.

After taking into account the normal wastage due to such factors, however, we have to look further for the practically complete elimination of seedlings at Kojonup in 1942. Although in the main this was a favourable year for subterranean clover and in many districts there was no substantial break after the opening rains in the middle of March, at Kojonup, very few plants from a substantial germination were able to survive the competition with five million erodium plants per acre for the small amount of moisture available. The drought resistance of the erodium is exemplified by the fact that a large proportion of the plants not only survived but were capable of making rapid growth with the advent of April rains.

In 1941, before being cultivated, both the Yornaning and Kojonup plots carried a dense growth of erodium but the efficiency of cultivation following the early rains in suppressing this species is shown by the low figures recorded in the 1941 plant counts (see Table 3).

In 1942, however, this species at Kojonup had increased by 1700 per cent. but at Yornaning the corresponding increase was less than 200 per cent. Possibly more dormant seeds may have remained in the soil but the fluctuation of this and other weeds at the different centres has a close linkage with the season and the condition of the soil, especially with reference to the nitrogen level as affected by the growth of subterranean and other clovers.

During the course of the investigational work particular attention has been paid to the seed aspect and, as previously mentioned, an attempt has been made to estimate seedling wastage. Table 4 summarises field observations, the results of laboratory germination tests and computed figures. For the period 1941-43 there was no reason to believe that the wastage figures derived did not represent the true position, in fact in 1942 soil germination tests under field conditions were conducted with both burr and hand cleaned seeds from the various plots, giving results which conformed with the laboratory tests. In 1944, however, a number of the plant counts made in the field exceeded the estimated seedling production. To take an extreme example, there were 1,216 seeds per square link on Yornaning plot 2 in 1944 but this was reduced to 470 in 1945, although the estimated germination based on laboratory tests was only 134. A large disparity exists without taking into consideration any seed formation in 1944.

Table 4.

SEEDLING WASTAGE.

	1941.					1942.				
	a.	b.	c.	d.	e.	a.	b.	c.	d.	e.
		%			%		%			%
Yornaning 1. ...	5·4	90	4·9	2·1	— 57	164	46	75	29	— 61
4. ...	5·4	90	4·9	3·0	— 39	330	46	152	41	— 73
2. ...	5·4	90	4·9	2·1	— 57	169	44	74	27	— 64
Wagin 1.	5·4	90	4·9	1·8	— 63	63	49	31	7·0	— 77
4.	5·4	90	4·9	2·0	— 59	40	34	14	7·2	— 49
2.	5·4	90	4·9	1·3	— 73	53	37	20	4·1	— 79
Kojonup 1. ...	5·4	90	4·9	2·2	— 55	100	43	43	0·1	—100
4. ...	5·4	90	4·9	2·1	— 57	153	26	40	2·8	— 93
2. ...	5·4	90	4·9	1·4	— 71	143	40	57	...	—100

	1943.					1944.				
	a.	b.	c.	d.	e.	a.	b.	c.	d.	e.
		%			%		%			%
Yornaning 1. ...	354	27	97	20	— 79	429	20	86	67	— 22
4. ...	398	26	92	30	— 67	1030	17	175	108	— 38
2. ...	489	23	111	21	— 81	1216	11	134	146	+ 9
Wagin 1.	213	25	54	10	— 82	590	29	171	271	+ 58
4.	111	26	29	14	—52	391	39	156	198	+ 27
2.	39	36	14	9	—36	445	33	142	207	+ 46
Kojonup 1. ...	31	...	...	3·1	...	79	31	24	40	+ 67
4. ...	207	...	...	7·0	...	878	17	140	140	...
2. ...	41	...	...	1·2	...	156	34	53	57	+ 8

	1945.				
	a.	b.	c.	d.	e.
		%			%
Yornaning 1. ...	473	12	57	51	— 11
4. ...	779	4	31	73	+135
2. ...	470	17	80	52	— 35
Wagin 1.	237	4	9	51	+467
4.	181	5	9	27	+200
2.	179	14	25	18	— 28
Kojonup 1. ...	296	20	49	15	— 69
4. ...	599	6	36	51	+ 42
2. ...	302	24	72	8	— 89

Explanatory.

a = Seeds per square link.

b = Laboratory Germination.

c = Estimated plants per sq. link.

d = Actual plants per sq. link.

e = Percentage Variation.

Further replications of the germination tests failed to alter the estimated figures and by reference to the seed content of the soil at the beginning of 1944 and 1945, it became obvious that the field germination in 1944 considerably exceeded the laboratory germination. The test samples were obtained when the soil seed estimations were made in January or February and we must conclude that subsequent processes in the soil substantially reduce the hard seed content and render germinable a larger proportion of the seed. Such processes may be attributable to temperature fluctuations, especially in the presence of moisture, the action of soil micro-organisms or even the "softening" of the seed coat by more direct chemical means and do not necessarily occur to the same extent each year. Although an increased germination of this nature is necessary to reconcile the estimated and actual seedling population it is possible for seeds in the ground to be destroyed by various agencies. With unprotected pastures the rabbit is a bad offender and uncontrolled fires play their part. Evidence of seed rotting has been noted both following summer rains and excessively wet winter conditions but no measurement of the significance of such losses is available.

It is apparent that laboratory germination tests are not always a reliable guide to the potentialities of a subterranean clover pasture, especially some years after establishment when normally there is an appreciable accumulation of hard seeds. The continued build up is reflected in the general decline of the laboratory germination figures for the samples taken from 1941 to 1945, especially in the last mentioned year, when, owing to a dry spring in 1944, samples from a number of plots contained few new burrs.

Although only germination figures have been given in the table, practically the entire remaining percentage in each case was comprised of hard seeds. In 1942, the year following sowing, the average germination for the nine plots was 41 per cent., but in 1945 the corresponding figure was only 12 per cent. This trend is shown clearly in Graph 4 representing the six plots for which complete figures are available. The improved seed setting in 1943, especially in the case of the Wagin plots, checked the downward movement of the graphs and, in the future, fluctuations can be expected to correspond with seasonal variations in seed formation.

Some details concerning the relationship between the burr and seed, the size of the seed and yields per acre are given in Table 2. Fluctuations due to seasonal conditions are apparent in all horizontal columns with the exception of that listing the weight of one seed. The weight of seed per gram of burr provides a good indication of the extent of seed setting during the previous year. In 1945 the "single seed weight" of the three Kojonup plots decreased but in the main this figure was comparatively uniform.

After three or four years of uninterrupted development a climax of the soil seed content can be expected although in later years the same figure may again be reached or even exceeded. It is apparent, however, from an examination of the "equivalent pounds per acre" column that three plots exceeded one-half ton of seed per acre in 1944 but owing to the comparatively poor seed setting in the dry spring of that year this figure was not reached in 1945. Such yield estimations are of value to the seed producer.

Germination
Plot 1
Plot 4
Plot 2
Yornaning
Wagin
50%
40%
30%
20%
10%
1942 43 44 45
42 43 44 45

Graph 4

SOIL CHEMISTRY.

As previously mentioned, prior to my association with the investigation comprehensive experimental work was carried out with various combinations of standard fertilizers and minor elements including magnesium, manganese, copper, zinc, boron, iron, antimony, tungsten, nickel, iodine, and cobalt. Following favourable reports from South Australia, molybdenum was also tried but the only indication under field conditions of a benefit due to fertilizer application other than superphosphate was obtained with potash which in some cases was slightly beneficial.

In an attempt to trace variations in the nitrogen level, soil samples taken from various sites in 1941 and 1942 were analysed by the Plant Nutrition Officer for ammonia and nitrate nitrogen. These analyses were conducted with the samples as received and then after incubation for one month in order to estimate the labile nitrogen content.

There was a certain correlation between labile nitrogen and soil type but the labile nitrogen status could not be linked with the stalling of subterranean clover. The amount of super. applied to the soil appeared to influence the quantity of ammonia produced on incubation. Mr. L. T. Jones who carried out the tests observed—"It is known that ammonification can be carried on by a wide variety of micro-organisms and also by enzymes, while nitrification is more specific. Certain of the ammonifiers may be particularly responsive to phosphate."

It was soon apparent that little conclusive information regarding variations in nitrogen status or other characteristics would be secured without a project entailing a considerable number of replications of samples taken at short intervals and commencing with the virgin soil. As a detailed project of this nature has not been possible the soil investigations have been discontinued.

ESTABLISHMENT OF CLOVER ON "STALLED" LAND.

In considering methods for the re-establishment of clover on "stalled" land, practicability was the primary consideration and bearing this in mind, cropping, along with the introduction of a suitable grass appeared to present the greatest possibilities. The following experiment was planned:—

Plot.	1941.	1942.	1943.
1.	Early subterranean clover.	Pasture.	Pasture.
2.	Oats, Wimmera rye grass, and early subterranean clover.	Pasture.	Pasture.
3.	Oats and Wimmera rye grass.	Early subterranean clover.	Pasture.
4.	Oats.	Oats and Wimmera rye grass.	Early subterranean clover.
5.	Fallow.	Oats and Wimmera rye grass.	Early subterranean clover.
6.	Control.	Control.	Control.

Experiments to conform with this time table were commenced in 1941 at the Narrogin School of Agriculture and on a property at Kojonup. Both sites were regarded as stalled clover pastures. Each plot consisted of one-fifth acre and the series at each centre was duplicated. Unfortunately it was necessary to abandon the Kojonup experiment in 1942.

All the Narrogin plots except the fallow and control were ploughed 2½in. deep and the necessary sowings made on 27th-28th May, 1941. The rates of seeding per acre were: early (Dwalganup) subterranean clover, 8 lb.; Fulgham oats, 40 lb.; Wimmera rye grass, 2 lb. and superphosphate was applied at 1 cwt. per acre. The soil was dry and friable and there was an abundant growth of erodium along with some subterranean clover. Plot 5 was later ploughed to a depth of 4in. and cultivated in the spring.

All sown plots yielded a heavy oat crop and the rye grass establishment was also good. Much of the erodium recovered following the autumn cultivation and was abundant on all except the fallow and especially on the control. Although the clover on plot 2 represented a satisfactory first year stand it was inferior to plot 1 which in turn was less dense than the control. In fact, based on the clover development of the control in this and subsequent years the "stalled" condition of preceding years was not maintained and ample evidence of a natural cycle influenced by seasonal variations was forthcoming.

In 1942, although the erodium was still plentiful there was a good stand of clover on plot 1, which closely resembled the control. The clover on plots 2 and 3 was fair with a vigorous growth of rye grass along with some self sown oats, and somewhat less erodium than on plot 1. Plot 4 carried a fair crop of oats and rye grass with sparse clover and erodium comparable with plots 2 and 3. The 1941 fallow plot was dominated by a tall, dense growth of cape weed which smothered all other species. This was mown when the cape weed commenced to flower in the spring.

The following year plots 1-3 showed little variation from 1942, erodium still being plentiful and clover varying from good on 1 to moderate on 3. There was an even stand of rye grass on plot 4, but the clover was sparse and both erodium and cape weed were plentiful. Plot 5 was similar but with somewhat more cape weed and less erodium. The clover was fair on the control but there was a strong development of barley, brome and silver grass intermixed with erodium.

In 1944, plot 1 deteriorated, the clover being sparse and the pasture consisting mainly of dense barley grass, erodium and cape weed. Plots 2, 3 and 4 showed improvement, having less weed growth than plot 1 and the rye grass stand being satisfactory. The clover on plots 2 and 3 was somewhat uneven but good in sections and superior in this respect to plot 4. The fallow plot was still dominated by cape weed and erodium with a sparse growth of clover. The control plot closely resembled plot 1 in all respects.

Very interesting results were apparent in 1945. Although plot 1 carried a fair stand of clover, there was an abundance of barley grass and silver grass. Some cape weed was also present but a surprising feature was the low erodium content. Plot 2 was an ideal dense stand of clover and rye grass with little cape weed, erodium or extraneous grasses. The clover and rye grass on plots 3 and 4 were also very good although they contained somewhat more cape weed than plot 2. The clover on plot 5 still remained sparse, being dominated by a strong growth of cape weed. The control was again comparable with plot 1 and obviously inferior to plots 2, 3 and 4, especially the outstanding plot 2.

Only plot numbers for one series have been mentioned in the above account but the duplicate series gave similar results.

A deteriorating early subterranean clover pasture. Erodium is the main intruder. (Photo: R. C. Rossiter.)

Observations.—Cropping with oats, along with Wimmera rye grass and subterranean clover and allowing the plot to revert to pasture the following season proved to be the most successful treatment, but the effect was not apparent immediately. Although typically stalled in 1940 there was a satisfactory stand on the control plots in 1941 and this was maintained to a greater or lesser extent, reaching the lowest ebb in 1945, the year in which the various cropping treatments, excluding the fallow, gave their best results. Under different seasonal conditions the effects may have become apparent sooner.

Croppings extending over a period of two years as represented by plots 3 and 4 eventually gave beneficial results but depressed the productivity of the pasture for a longer period without any obvious advantage so far. Fallowing proved entirely unsatisfactory and disappointing results following fallowing could only be avoided by frequent workings to reduce the cape weed to reasonable proportions. The sowing of further clover seed alone, as on plot 1, while ample remains in the soil for regeneration of the pasture did not prove advantageous.

The treatment that gives best results for one pasture may not be most effective for another, even in the same district, but the results of the Narrogin experiment and observations on farmers' properties in several districts lead to the conclusion that shallow cultivation and cropping with oats and Wimmera rye grass, is, in general, the most effective practical measure against clover stalling. This cropping can be done dry, in which case, if the pasture has not deteriorated badly, there is seldom any necessity to re-sow with clover. It is advisable not to delay the cropping until the pasture has declined to an appreciable extent, and a 4-5 year programme has much in its favour. While the soil seed content is high, even if the cropping is not done until immediately after the germinating rains, the necessity for sowing more seed seldom arises.

GRASS ESTABLISHMENT AND CULTURAL TREATMENTS.

(a) *Establishment of Grasses.*—Besides improving the nutritional level of a pasture by the introduction of suitable grasses it was felt that such non-leguminous plants could play their part in modifying the species cycle which included a marked deterioration of the sward.

In 1942 an experiment was commenced at Katanning utilising four different grasses, and having six replications of six series of plots, each plot being 1/100th acre. The sowings were as follows:—

1. Bromus carinatus ... 8 lbs. per acre + early (Dwalganup) subterranean clover 8 lbs. per acre.
2. Wimmera rye grass ... 2 lbs. per acre + early (Dwalganup) subterranean clover 8 lbs. per acre.
3. Phalaris tuberosa ... 2 lbs. per acre + early (Dwalganup) subterranean clover 8 lbs. per acre.
4. Perennial veldt grass ... 2 lbs. per acre + early (Dwalganup) subterranean clover 8 lbs. per acre.
5. Early (Dwalganup) subterranean clover 8 lbs. per acre.
6. Control (natural pastures)..

Super. was applied annually at the rate of 1 cwt. per acre. The soil consisted of a brown sandy loam originally carrying York gum, flooded gum and some wandoo. The paddock was cleared many years previously and had not been sown down to clover. Erodium was abundant.

It was intended that this experiment should be of a comprehensive nature and that estimations of yields should be made and species trends recorded. Regulated grazings were also proposed. Although later it was found impossible to maintain this programme, some useful general observations were possible.

Plant counts made at the end of July, 1942, revealed a satisfactory establishment of all sown species as shown by Table 5. The plant numbers represent the average of 60 one square link counts comprised of ten throws for each of six replications.

TABLE 5.—ESTABLISHMENT COUNTS.

	Series.						Ests. viable seeds sown per sq. link.	Per cent. established
	1.	2.	3.	4.	5.	6.		
Bromus carinatus ...	3·4	...	...	...	...	...	4·5	76
Wimmera rye grass ...	...	3·1	...	...	...	...	3·5	89
Phalaris tuberosa ...	...	...	1·5	...	...	...	4·5	33
Perennial veldt grass ...	...	...	...	1·4	...	...	3·0	47
Subterranean clover ...	3·8	3·8	3·0	3·0	3·8	...	5·3	66
Erodium botrys	1·9	1·6	1·7	1·9	2·0	1·8	...	...
Capeweed	1·4	1·4	1·0	1·2	0·7	0·6	...	...
Annual grasses	0·8	0·7	1·4	0·9	1·9	2·4	...	...

The excellent first year stand of clover was maintained and in the three subsequent seasons very good growth was made. Bromus carinatus was of slender, erect habit and showed little tendency to stool. It matured early

and did not appear to be a suitable grass for the conditions. In the year following establishment, Wimmera rye grass was sparse and was a minor component of the sward. A marked improvement was shown in 1945, however, after three seasons of clover. It was noticeable at this stage that where the rye grass was most plentiful erodium and cape weed were least conspicuous.

The perennial grasses, Phalaris and veldt also tended to reduce weed development, but unfortunately these species persisted only in sections in sufficient quantity to have an appreciable influence on the sward.

A reasonable conclusion to be drawn from this experiment is that the establishment and maintenance of a suitable grass, preferably a perennial, would do much to create botanical equilibrium in the pasture, at the same time improving the palatability and nutritional level of clover dominant swards. The difficulty, however, is to locate a species which will persist under grazing conditions in the lighter rainfall areas. Encouraging results have been secured with Phalaris and perennial veldt in the more favoured localities relative to moisture, but Wimmera rye grass remains the most widely sown species. It has the disadvantage of being an annual but is more readily established at a lower cost.

"Stalling" of subterranean clover has also been experienced in the lighter rainfall areas of South Australia where grasses have also been used as a corrective. Cook (3) reports that the field which has given the greatest trouble with cape weed at Kybybolite is the only one originally established with subterranean clover alone. No dominance by weeds such as erodium and cape weed has occurred on fields sown with grass as well as clover when efficiently managed and the proportion has varied with the seasons, the clover predominating during years of good rainfall and cold winters. Erodium has not seriously affected pastures in districts exceeding 20 inches annual rainfall but has been more plentiful in the 17—20 inch belt.

(b) *Mowing.*—With a view to ascertaining the effect of mowing on the botanical composition, experiments were carried out at Narrogin and Kojonup in 1943. The layout provided for six replications of alternative strips 25 links wide and one chain long to be mown and left uncut. The mowing was carried out on 24th September at Narrogin and 8th October at Kojonup when the clover was up to one foot high and at both sites contained erodium, cape weed and annual grasses. At Narrogin there was also a quantity of self-sown oats present. The clover had seeded down and the weeds carried immature seeds. Following mowing, the plots were raked and the hay removed.

When observations were made at the beginning of November the erodium, and to a lesser extent, cape weed had produced seeds from laterals developed following mowing. On 22nd September 1944, samples were taken to enable a botanical estimation on an air dry basis to be made. Ten grabs of approximately the same size were taken from each plot and the percentage content of each species is detailed in the Table 6. At the time of sampling the reduction in the barley grass content on the mown plots at Narrogin was very noticeable. Analyses of these figures carried out by Mr. T. N. Stoate (Conservator of Forests) showed that at the .05 level the mowing caused an increase in the cape weed content at Kojonup, but there was no significant effect on the other species. At Narrogin, however, there was an increase in the proportion of both the clover (.01 level) and the erodium (.05 level), while the grass content was reduced (.05 level). There was no significant difference due to treatment in the case of either the cape weed or oats.

TABLE 6.

EXPERIMENT 1.—KOJONUP.

	Not Mown.							Mown.						
	Plot.						Average.	Plot.						Average.
	1.	4.	5.	8.	9.	12.		2.	3.	6.	7.	10.	11.	
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Subterranean Clover	43·4	54·0	47·6	41·6	49·5	40·9	46·1	56·8	49·9	53·5	52·3	32·6	46·7	48·6
Grasses	25·6	26·6	20·1	17·6	10·2	14·8	19·2	15·5	15·7	18·0	12·8	8·2	11·8	13·8
Erodium	15·9	12·9	22·1	33·8	32·2	29·1	24·3	10·4	10·0	12·0	23·8	25·4	26·0	17·8
Cape Weed	15·1	6·5	10·2	7·0	8·1	15·2	10·4	17·3	24·4	16·5	11·1	33·8	15·5	19·8
EXPERIMENT 2.—NARROGIN.														
Subterranean Clover	13·0	10·2	14·8	17·3	9·3	22·0	14·5	26·9	23·2	49·1	36·1	30·7	23·5	31·6
Grasses	70·0	27·2	27·0	65·3	74·8	49·7	52·4	15·6	30·5	20·3	8·4	40·7	24·7	23·4
Erodium	12·8	8·9	5·0	15·3	6·7	14·8	10·6	16·1	13·2	27·1	51·4	20·5	39·1	27·8
Cape Weed	·1	...	·2	1·0	9·2	13·5	4·0	...	·3	3·5	2·8	8·1	12·7	4·6
Oats	2·8	53·7	53·0	1·1	...	...	18·5	41·4	32·6	...	1·2	...	...	12·6

(c) *Phosphate Applications.*—The stalling of clover has been attributed to the effect of residual phosphates in the soil. The theory is based on the assumption that they are more readily available to weeds such as Erodium botrys than to subterranean clover and that continued applications of phosphates will increase the soil residuum and favour the weed growth.

In 1941 an experiment was commenced at Kojonup to ascertain the effects of various phosphate treatments in the form of both superphosphate and basic superphosphate on the botanical composition of an already established pasture. Treatments consisted of 2, 4 and 8 cwts. of superphosphate per acre and basic superphosphate at rates equivalent to the P_2O_5 content of the super dressings. Five replications of 1/50th acre plots were employed and topdressing at these rates was carried out in the autumn of 1941, 1942, 1943 and 1944.

Observations have been made over a period of five years and at no stage during that time has it been possible to segregate treatments by virtue of their effect on botanical composition. The control plots which received no fertilizer could usually be detected with some degree of certainty but rather due to lack of growth than any variation in species content, although latterly there was a tendency for the clover to deteriorate.

Although no quantitative estimations were made it is possible to give an impression of variation in weed content of the experimental site during 1941-45. When the initial topdressings were made in 1941 there was a good stand of clover with a moderate amount of erodium and cape weed which the following season had become conspicuously more abundant with the clover somewhat uneven. In 1943 the weed content was again at the 1941 level with a corresponding growth of clover. In 1944 a dense growth of clover contained annual grasses, mainly barley and silver grass, and cape weed as its main impurities, erodium being inconspicuous. The following year, although there was still a good stand of clover, the erodium and cape weed had again increased and the grasses had diminished.

By reference to the rainfall charts for Kojonup it will be noted that in 1942 and 1945 the first substantial rains fell in March and were followed by a comparatively dry period before the commencement of regular winter rains. In 1941, 1943 and 1944, however, there was no extended dry period following the opening rain. The first mentioned set of conditions favours the erodium to the detriment of the clover as this species germinates and makes growth with a minimum of moisture. If the moisture is sufficient to induce germination of the clover there is the risk of malting due to the dry period. On the other hand if germination does not occur, the erodium has a decided advantage when the clover seedlings appear later in the season. Erodium causes least concern when the opening rain is a sound one and is followed regularly by further falls.

DISCUSSION AND CONCLUSIONS.

The stalling of subterranean clover as experienced in the Great Southern District, cannot be attributed to any single factor. Observations over a period of five years lead to the conclusion that there are two dominant influences, firstly climate and secondly the effect of the clover and associated phosphate dressings on the soil. Both are capable of inducing a marked modification of the botanical composition of a pasture and have a decided bearing on weed competition. Other factors are also at work to a greater or lesser extent. Insects, especially red mite and lucerne flea can play their part in reducing a stand of clover and this aspect has been discussed by Norris (5). Again there is evidence to indicate a deficiency

of copper and possibly magnesium on some properties but such cases are not general. It has been suggested that magnesium increases the depth of root penetration of clover in which case any benefits from magnesium dressings could be expected in adverse seasons. Injudicious grazing can also play its part and further mention of this is made later.

Seasonal conditions affect not only the growth but the density of a clover sward and also the nature and quantity of extraneous species. A favourable growing season may be classed as one in which the opening rain is substantial and is followed by regular precipitations until late in the spring. Weed growth, is favoured by an early light fall. Erodium botrys in particular germinates with a minimum of moisture, which if insufficient to germinate the clover, gives the erodium an immediate advantage. The drought resistance of this weed is particularly high and a very severe dry period is necessary to cause a high percentage of mortality. On the other hand, if the moisture is sufficient to produce clover seedlings there is very often a high mortality rate, especially if there is a lengthy period before the commencement of the regular rains.

It has been established that drought resistance is not so much concerned with conservation of water or economy of transpiration but rather with the capacity to endure wilting unharmed. Some plants affected by drought resume normal growth following rain while others never completely recover. The degree of resumption of growth is therefore an appropriate measure of drought resistance. Using this conception of drought resistance Erodium botrys is at an appreciably higher level than subterranean clover. Pavlychenko and Harrington (6) have shown that the competitive efficiency of any species is related to the ability of the plant to develop rapidly following germination. They conclude that in competition, supremacy may be obtained by the species or variety which is able by greater physiological activity and morphological adaptability, to utilize the environment more efficiently. A better example than erodium under adverse conditions early in the season would be difficult to find.

Showing recovery of a stalled pasture in a favourable season (1942). The pegged plot has been kept free of weeds.

In 1942 and 1945 subterranean clover dominated most swards and erodium was relatively inconspicuous. Large tracts of country on which clover had not been noticed previously carried good stands. The rainfall graphs show clearly that the autumn rains in these two years conformed to the optimum requirements of the clover as already described. The low temperatures experienced during the winter of 1942 provided a deterrent for weed growth for although the clover made little growth it was not retarded to the same extent as the erodium and cape weed. This observation is supported by experiences recorded by Cook (3) at Kybybolite in South Australia. There is a ready correlation between unfavourable, intermittent autumn rains and both clover growth and species content. There are instances of large districts and even practically the entire early clover belt being affected. 1940 was a year of low rainfall and also in many districts early germinating rains in March and even January were followed by extended dry periods. These conditions were reflected in the poor stands of clover and the large areas classed as being stalled. Experimental sites selected for this very reason produced satisfactory clover pastures the following year which in most districts provided favourable conditions.

The outstanding example of a pasture at Kojonup "stalling" in the season following sowing due to practically complete malting following March rains in 1942 has already been described in detail. It is sufficient to state that the "hard" seed reserve from one season's seeding was sufficient to enable the pasture to become re-established during the following favourable seasons.

As already mentioned, the nature of the spring rains may also be of significance in determining the stand of clover the following year. Large fluctuations in clover seed yields recorded on experimental plots were directly associated with variations in the moisture content of the soil at the time of seed setting and development. No estimation, however, revealed insufficient seed to produce a moderate stand the following season and this aspect is of less importance than the destruction of seedlings due to malting. Weeds such as erodium, mature earlier and their seed setting is unlikely to be affected by a dry spring.

Closely linked with the climatic factor is the effect of the clover growth and associated phosphate dressings on the nitrogen content of the soil and in consequence, the botanical composition of the pasture. Although chemical analyses of a limited number of soil samples taken during this investigation have not disclosed any definite correlation between soil nitrogen status and "stalling" there is ample evidence from a number of sources to show that the nitrogen level is increased by the application of phosphate in association with grazing. This applies to natural pastures as well as developed subterranean clover pastures although more accentuated in the latter case. In South Australia (4) under rainfall conditions similar to those existing in the early clover belt of this State, the nitrogen content of the top four inches of soil was nearly doubled by regular phosphate dressings on natural pasture over a period of twenty years. Such natural pasture could be expected to contain an appreciable proportion of volunteer legumes.

Top dressing with superphosphate, therefore, besides stimulating the growth and multiplication of clover and weeds due to the available phosphate, increases the fertility of the soil mainly by stimulating the activity of nitrogen fixing bacteria associated with legumes. This increased nitrogen content due to symbiotic action creates a condition which favours non-legumes to the

detriment of the clover and in consequence has a strong influence on the composition of the pasture which passes through a botanical cycle modified however, by other factors, especially the climate. This cycle includes, as the two extremes, pastures of pure subterranean clover and those dominated by non-leguminous species of which Erodium botrys, cape weed and grasses are the major components.

It is reasonable to expect that the higher the rate of phosphate application (within reason) the greater the tempo of these processes will be and the sooner the cycle is likely to reach the stage where the clover is dominated by weeds. Regular observations from the time of the initial sowing of plots receiving varying phosphate applications have shown this assumption to be correct although when a pasture has been established for a number of years and has reached a climax, even though an unstable one, the quantity of phosphate applied does not appear to be an important factor in determining botanical composition.

When the weed phase of the cycle is reached the climatic factor already discussed assumes maximum proportions and the balance inclined in favour of the weeds can be completely tilted by certain seasonal features. The clover element of a pasture can be very sorely depleted by malting under low soil moisture conditions even when weeds are not prevalent. The risk of stalling increases, however, as the clover and associated weed growth becomes more dense and the competition, especially for moisture more intense. A number of examples have been noted of scattered clover plants experiencing little competition from their own or other species remaining green considerably longer than nearby crowded plants. Experiments conducted by Ashby and May (1) in New South Wales indicated that a high level of nitrogen, possibly through its effect on the growth rate, renders the Fulghum variety of oat more susceptible to the harmful effects of drought. The dry conditions were not only reflected in the number of plants killed, but also in the effect on subsequent growth of plants that survived. This may represent another influencing factor although there is no information regarding any variation in the reaction of different species.

Although the question has already been answered in an indirect way, it is reasonable to ask, as the climatic factor is considered of such importance, why do pastures usually stall after they have been established for say five or six years. We have the example, already discussed, of a pasture at Kojonup established on old land stalling the year following sowing but it is more usual for the trouble to occur after a number of years, for during that period the pasture normally passes through the phase of the cycle which creates conditions favourable to weed growth and renders the clover more susceptible to the vagaries of the season. As mentioned previously, the vulnerable period is reached more rapidly with higher phosphate applications but this does not necessarily provide argument for reduced super. dressings. Within practical limits the pasture yield is dependent on the amount of phosphate available and if the application rate is reduced the carrying capacity of the pasture will be affected.

When consideration is given to the many factors, large and small, influencing the growth of subterranean clover in the low rainfall belt, unhindered development of this species cannot be expected. The main weed competitor, Erodium botrys, is more drought resistant and has a shorter growing period than Dwalganup subterranean clover. When the length and continuity of the season meets the requirements of the clover as is usually the case in the western portion of the early belt, stalling in its acute sense is not experienced and any reduction in the clover content of a sward is repaired by cropping. When such seasonal conditions

do not apply, obviously they conform closer to the requirements of such weeds as erodium and it is only natural for these weeds to assert themselves under such circumstances.

A pure stand of subterranean clover is far from being an ideal pasture and there is an immediate need of a suitable grass to improve the nutritive level of pastures in the Great Southern District. Besides increasing their value for stock, experiments conducted at Katanning have shown that grasses play an important part in reducing the proportion of weeds. Perennials are most effective in this respect but Wimmera rye grass was also found useful. As some difficulty is experienced in establishing and maintaining such grasses as Phalaris tuberosa and perennial veldt grass over extensive areas in the early clover district, Wimmera rye grass would appear to be the most suitable species to employ until further agrostological advances are made. The incorporation of a palatable and nutritious grass is equivalent to replacing a proportion of the non-leguminous species of a pasture with a more useful component which also assists in maintaining the clover proportion at a satisfactory level.

Experiments conducted at Narrogin and the experience of some farmers have shown that pastures tending to deteriorate can be revitalised by cropping. Deep ploughing is inadvisable and satisfactory results have been achieved by making a dry shallow sowing of oats, preferably with Wimmera rye grass, using a combine. The surface scarification improves the soil texture for the growth of the clover and also allows greater advantage to be taken of any early rains. If sowing cannot be carried out dry, it should not be long delayed after the germinating rains or a big loss of clover seedlings will result. Early rains sufficient to germinate erodium with little clover or if the clover malts leaving the weeds, provide excellent opportunities to check the erodium and, at the same time sow a crop if desired. By cutting for hay and removing the crop, theoretically at least, the soil nitrogen level is decreased but improved clover stands have resulted following cropping and grazing. Some farmers have successfully adopted a four year rotation consisting of pasture for three years and a crop in the fourth. Field experience and evidence from some experimental plots indicate that surface working of the soil even without cropping, prior to or immediately following the first germinating rains, benefits the clover. An increase in vigour has been observed following the gathering of seed, especially from old pastures. Seed harvesting entails surface working of the soil to "lift" the burrs and this cultivation can be, at least, an indirect factor. Some farmers favour the use of a combine or drill in preference to a broadcaster in order to scarify the surface of the soil when applying the superphosphate dressing. There is scope for further investigational work in this direction, particularly with reference to the most satisfactory cropping programme. This may be found to vary for different districts.

Cape weed has been reduced by heavy grazing for short periods, especially at the flowering stage, although paddocks are usually too large to secure maximum results. Stock are not a satisfactory agency for suppressing erodium as it is not eaten readily, especially when nearing maturity. For this reason excessive grazing can actually be detrimental to a pasture in which erodium is abundant and clovers represent a palatable minority. Stock then tend to further reduce the clover to the advantage of the less palatable weeds which they avoid. Mowing has caused a reduction in the grass content the following year but does not appear to have any lasting remedial effect on a deteriorated pasture.

ACKNOWLEDGMENTS.

I wish to acknowledge the support and assistance of Mr. G. K. Baron Hay (Under Secretary for Agriculture) and Dr. L. J. H. Teakle (Plant Nutrition Officer), Mr. I. Thomas (Superintendent of Wheat Farming) and Mr. M. Cullity (Superintendent of Dairying) who comprise the committee associated with this investigation. Also other fellow officers of the Department of Agriculture, especially Mr. A. S. Wild who was co-worker in the earlier stages and Miss M. Dolley, who assisted with the seed estimations and preparation of graphs. The copying of graphs and charts was undertaken by Mr. P. Stanley, Chief Draftsman, Lands Department, to whom I am indebted.

Thanks are also due to the many farmers who provided information and practical suggestions concerning the problem when a general survey was being carried out, especially those who made areas available for experimental work and rendered assistance, at times, at considerable inconvenience to themselves. I will be excused for not listing them individually as many farmers were concerned.

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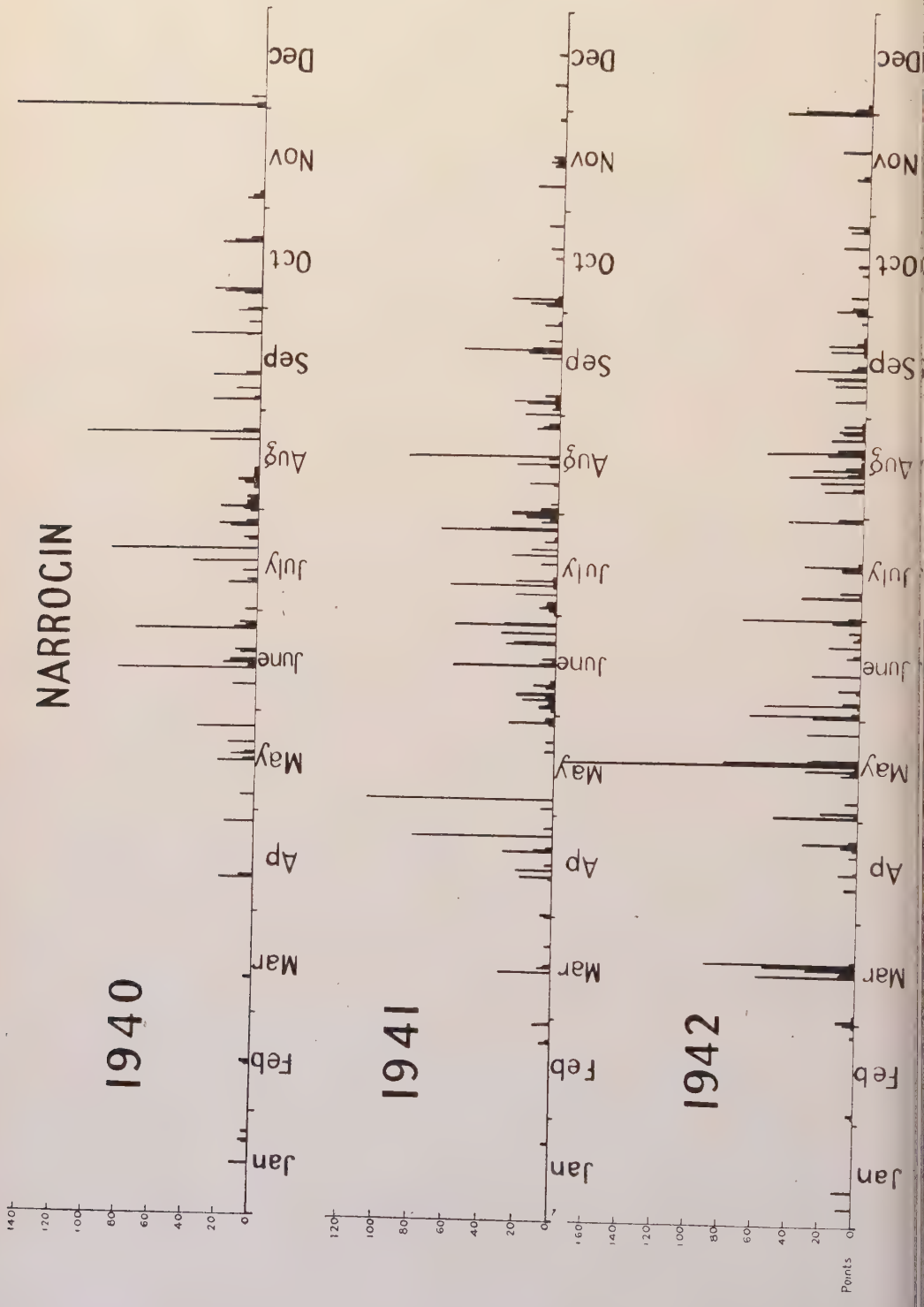
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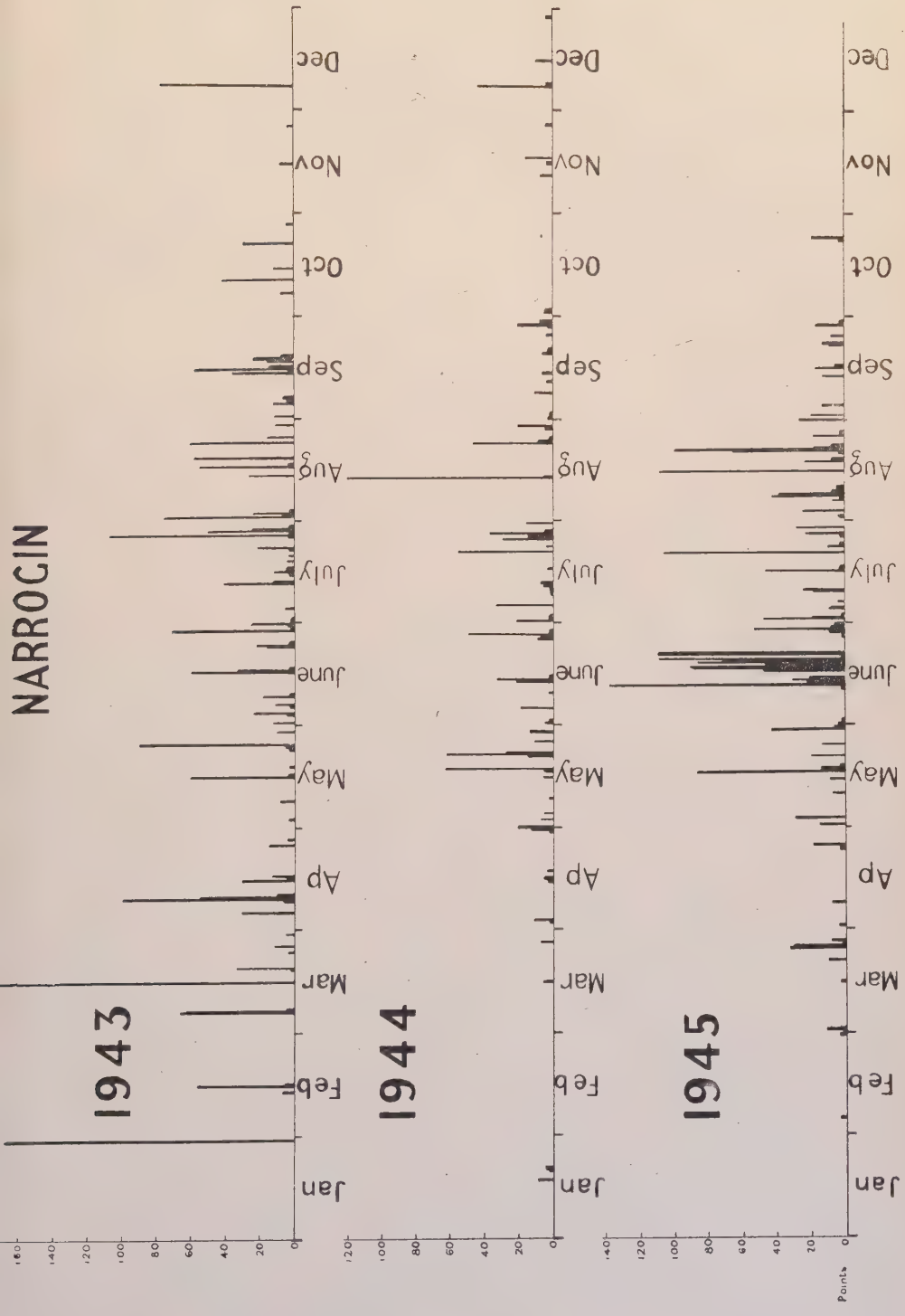
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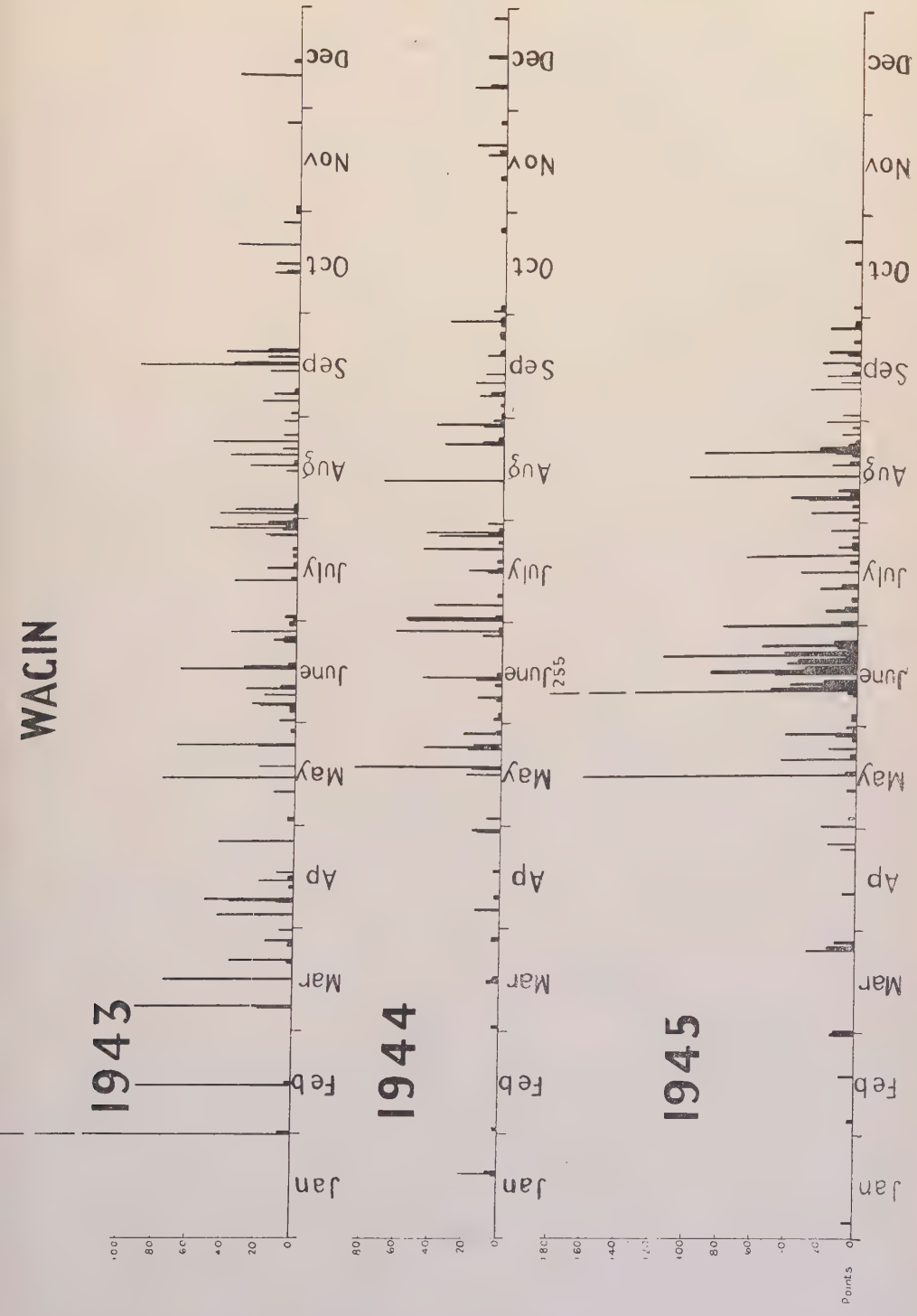
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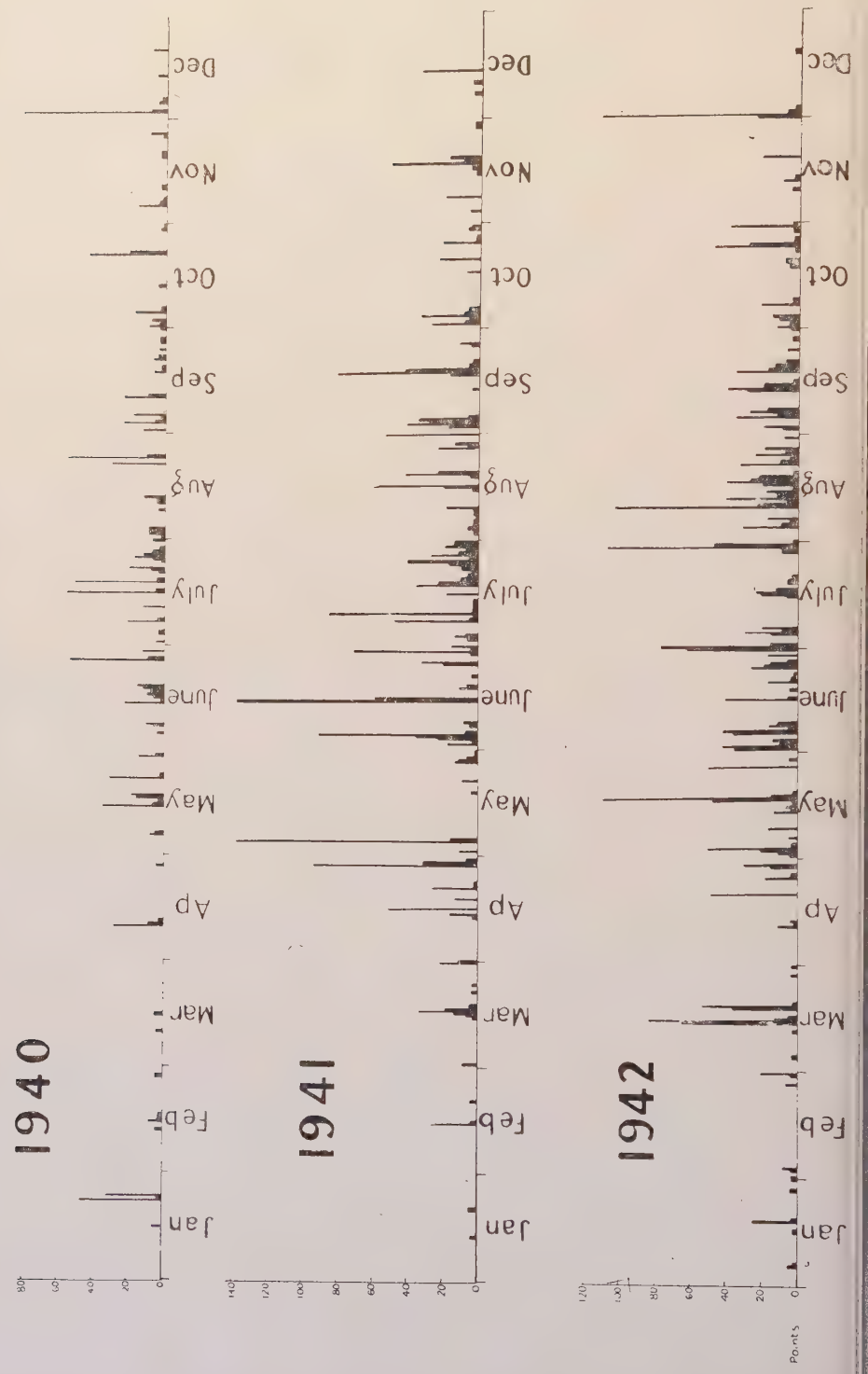
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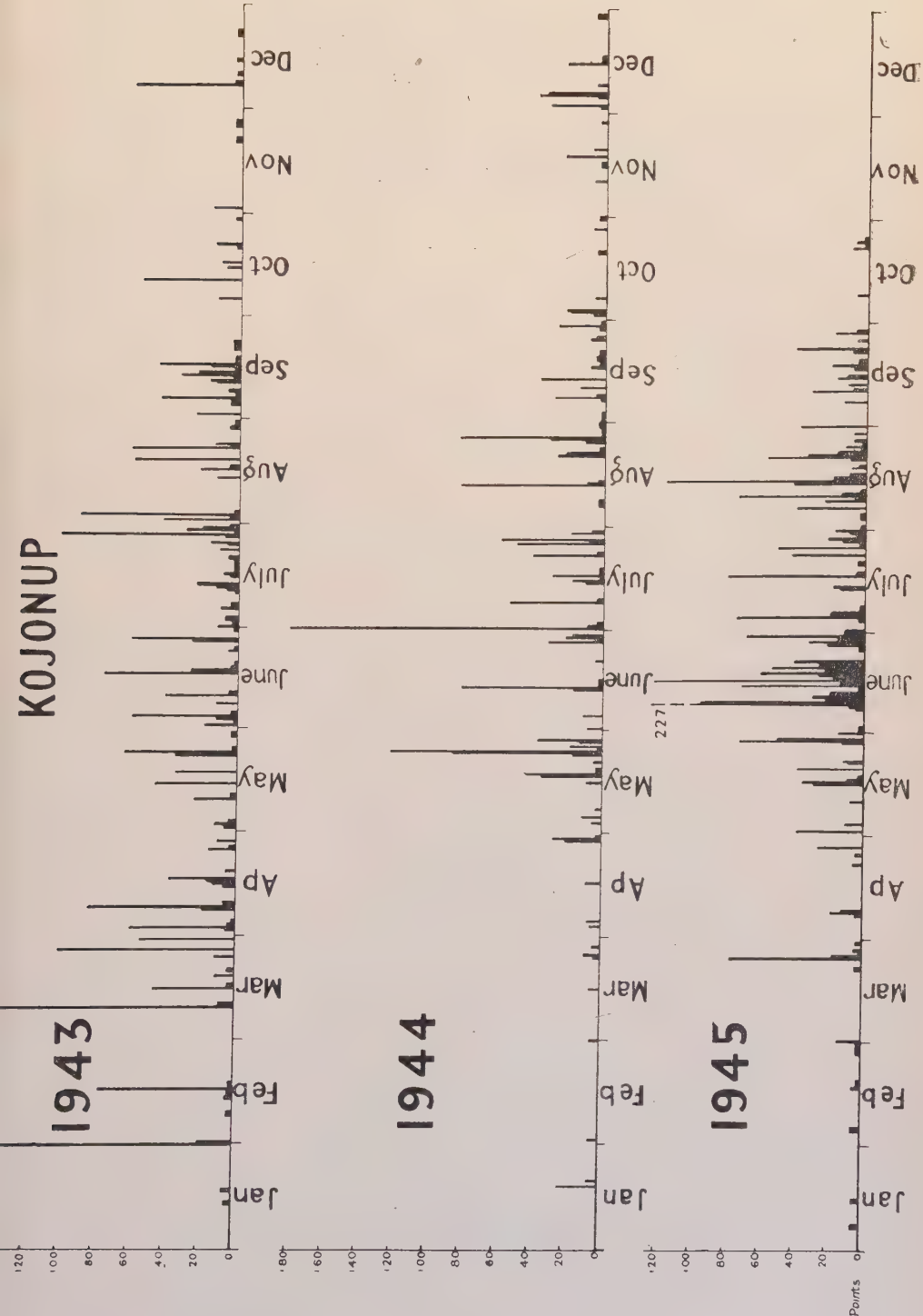
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Cobaltised Superphosphate.

A CORRECTION.

By L. J. H. TEAKLE.

IN drawing attention to the cobaltised superphosphate in the control of cobalt deficiency disorders of stock in the December, 1945, number of this *Journal*, page 304, it was stated—

> "It is of interest that the discovery of cobalt deficiency as the cause of a stock ailment was made in Western Australia."

It is regretted that reference was not made to the work in the laboratory of the Division of Animal Health and Nutrition (now the Division of Biochemistry and General Nutrition) of the C.S.I.R., in which the initial discovery of cobalt as a factor in animal nutrition was made. Mr. H. R. Marston, chief of this division, has pointed out that the discovery of cobalt as an active agent in curing and preventing a stock ailment was made in his laboratory by Lines, in 1934. This was reported by Marston (1935) and Lines (1935). In this instance, cobalt was used in the investigation of "coasty" disease, which is now known to be due to a deficiency of both cobalt and copper. It was on account of this dual deficiency that "coasty" disease was not referred to in the note recommending the use of cobaltised superphosphate in Western Australia for areas where the Denmark wasting disease is liable to occur.

Denmark wasting disease of Western Australia is apparently related solely to cobalt deficiency. There is no evidence of any other element, such as copper, being directly involved. The discovery of cobalt as the biologically potent element in the control of wasting disease was made in Western Australia by Underwood and Filmer (1935), a few months after the finding of the importance of cobalt as one of the factors in "coasty" disease by Lines.

It is of interest that 28 tons of cobaltised superphosphate have been sold in Western Australia in 1946 to date. The success of this fertiliser in New Zealand warrants an extension of its use in this State.

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"Wither Tip" of Apple Trees.

By T. C. DUNNE, Horticultural Research Officer.

IN 1938 there were reported the results of an investigation into the disease of apple trees known as "wither tip" or "summer dieback." It was shown at that time, that the condition resulted from a deficiency of copper for the normal growth of trees. It was also demonstrated that satisfactory growth could be obtained by applying copper sulphate (bluestone) to the soil around the trees or temporarily, by spraying in late November or early December, with Bordeaux mixture.

For much of the time during the intervening years, copper salts have been in short supply. In addition, many orchards have, of necessity, not had the attention which would ordinarily have been given. As a result, there are, in some districts, many trees to be seen which show evidence of copper deficiency.

Where treatment of diseased trees has been undertaken the results have been very gratifying. It is, therefore, considered advisable to draw the attention of orchardists to the benefit to be derived by making good such deficiencies.

By way of review, the following extract which concerns symptoms, is taken from the original article—

> "Badly diseased trees are usually characterised by a stunted bushy growth habit due to inability to develop a leader system.
>
> "The disease usually develops on vigorously growing shoots. During November or December, brown spots appear on the terminal leaves. Small necrotic areas are next noted. Leaves developed thereafter are more severely affected and eventually wither and fall. This condition is followed by the withering and death of the upper portion of the shoot where three to twelve inches of growth may be affected."

A typical case of "wither tip" is shown in Fig. 1.

Fig. 1.

The application of copper may be made in a number of ways, some of which are more effective than others. These include:—

(a) Spraying with Bordeaux mixture in November or December. This method gives almost immediate response, but the effect may only last for the one season. A 3:4:40 mixture is effective.

(b) Spraying with Bordeaux mixture during the dormant period. Satisfactory responses have been obtained in some cases by this method. A strength of at least 6:4:40 should be used.

(c) Application of copper containing compounds to the soil. This method is quite effective though the response may not be obtained the first season following application . The material should be applied to the soil in August in a band a' out three feet from the trunk in the case of small trees, or at about the drip ring in the case of larger trees. For quicker results the application should be dug in about spade depth.

Copper sulphate has been used in all experiments at the rates of 1 lb. for a small tree and 2 lb. for a larger one. However, the results secured by departmental officers using copper containing ores on other crops, indicate that such ores could be successfully used.

(d) Combination of soil application and spraying. Where trees are badly affected, both soil application and spraying are recommended for quick recovery. The soil application made in August would be followed by a spraying in early summer. Such treatment may last for many years or may even supply such stimulus that further treatent is not needed.

The benefit to be obtained for supplying copper in deficient areas has been well illustrated by the results obtained in a Young's Siding orchard. At the time the applications were made the trees were seven or eight years old and the effect of the deficiency in restricting growth is shown by the Figs. 2a and 2b, of two trees taken at that time (1940).

Fig. 2a.—Yates, 1940.

Fig. 2b.—Dunn's Seedling, 1940.

Copper treatments (soil and spraying) were continued on these trees, partly to determine whether copper poisoning would develop. At the end of four years, it was deemed advisable to discontinue applications. However, Figs. 3a and 3b, taken in 1945, clearly illustrate the improvement which has been achieved.

Fig. 3a.—Yates, 1945.

Fig. 3b.—Dunn's Seedling, 1945.

In addition to the above, a number of unthrifty trees which were not showing severe "wither tip" symptoms have since been given treatment with copper by the owner. These trees have shown excellent response and there is every prospect that a satisfactory orchard will be obtained from trees which, at one stage, were anything but promising.

Manganese Deficiency of Apple Trees.

By T. C. Dunne, Horticultural Research Officer and A. T. Gulvin, Horticultural Instructor.

A FEW years ago an investigation was begun of a diseased condition of apple trees in an orchard in the Albany district, and of a similar one in an orchard in the Mt. Barker district. As a result of tests in which various substances were applied to the trees by means of limb injections, both solid and liquid, by sprays and by soil applications, it was proved that the trouble was due in both cases to an insufficiency of manganese for normal growth. Numerous leaf samples have been analysed including those from healthy and unthrifty trees, from trees supplied with manganese and from others not so treated, in order to determine for this element, the leaf contents essential to healthy growth.

It has not only been found that manganese deficiency exists in a number of districts but also that, in some areas, the incidence of the disease is increasing. Furthermore, although it is possible to bring about a fairly rapid cure for some

aspects of the disease, it is not easy to stimulate new growth in trees which have suffered from deficiency for a number of years. For this reason, it is strongly recommended that attention be given as soon as it becomes certain that a deficiency exists.

SYMPTOMS OF MANGANESE DEFICIENCY.

The effect of deficiency of manganese in apple trees is most readily recognised by inspection of the leaves. In the illustration below, a normal leaf from a Dunn's Seedling tree is compared with leaves from trees of the same variety showing various degrees of deficiency.

1. 2. 3. 4.

Fig. 1.

The leaf marked 2 in the illustration shows the type of leaf symptom obtained when the disease is not very severe. If half or more of the leaves on the tree are so affected, immediate attention is warranted. In more severe cases, the green colouring of the leaf remains only along the main veins as is illustrated by leaf 3. The other leaf 4 illustrates the condition of acute deficiency when very little green colouration is found. Such leaves are usually very thin, are easily bruised by the wind or by handling, and often develop scorched edges.

The effect of deficiency on the trees is shown by a general stoppage of growth. The foliage is often sparse which is partly due to a reduction in the number of fruit spurs, a condition which is characteristic of the disease. This, of course, is usually followed by a small fruit crop the following year—deficient trees yield poorly.

The fruit itself may be affected. In the cooler districts Dunn's Seedling apples often develop some red colour but this may be accentuated by manganese deficiency. With varieties such as Yates, which may set a heavy crop on the existing spurs, the fruit from affected trees is sometimes appreciably reduced in size probably due to the lessened carbohydrate (e.g. sugar) formation consequent upon the lack of chlorophyll in parts of the leaves.

INCIDENCE OF THE DISEASE.

There is no doubt that the severity of the disease varies with seasonal conditions. Trees which in a good rainfall season show little or no sign of deficiency are markedly affected during a dry summer. Similarly, under such dry conditions, trees which normally are only slightly affected develop all the symptoms of acute deficiency. For this reason, symptoms have been noted during the past three seasons in those areas where the less than normal rainfall has had most effect in other ways. In this connection, it is believed that the reduction in the soil moisture seriously reduces the availability of manganese to the trees.

As mentioned above, deficiency symptoms have been noted in a number of apple growing areas. At Kendenup, which has a lower annual rainfall than most other apple districts, the disease has become rather widespread. Trees showing deficiency, in some cases acute, have also been found in the King and Kalgan River areas, at Mt. Barker, at Denmark, at Donnybrook and in the hills east of Perth.

There is some variation in the soil types with which manganese deficiency is related, but usually they are gravelly or gritty loams underlain by clay at shallow depths. Conditions appear to be worst where light or very gravelly surface soils are encountered.

TREATMENTS AND RESPONSES.

Of the treatments tested to date, the most effective in securing quick response is that of spraying the leaves with manganese during November or early December. For this purpose a "manganese burgundy mixture" has been used. The mixture consists of 4 lb. of manganese sulphate and 4 lb. of washing soda to 40 gallons of water. It is in no way harmful and if the leaves are thoroughly wetted, a healthy green colour will be obtained during the season of application.

On no account should lime be used as a substiute for washing soda, nor should lime containing spreaders be used. The use of lime with manganese results in the formation of an insoluble compound which is ineffective for the purpose in mind.

Soil applications of manganese sulphate have also given satisfactory results but may not take effect the first season following application. A good deal of the manganese applied is apparently fixed by the soil—at the least some of it is rendered temporarily unavailable. In England, it is reported that trees failed to respond to soil applications and this method is not recommended there, but in this State it has been used quite successfully. It is recommended that 2-4 lb. of manganese sulphate per tree, depending on its size, be applied in August in a band 12-18 inchs wide at about the drip ring of the tree. Favourable response would be hastened if the material were dug in to spade depth.

Where possible, and with trees showing acute deficiency, the soil application in August, followed by the spray in the early summer, should repay the cost and labour involved.

The benefits of treatments are demonstrated in the illustrations below showing Dunn's Seedling trees at King River. Figure A shows an affected tree with lack of growth and sparse foliage. From this tree about one bushel of fruit was picked. The next figure (B) illustrates the effect of soil treatment with manganese sulphate on a nearby comparable tree from which over four bushels of fruit were obtained. The other figure (C) of a larger tree shows the response to spraying with "manganese burgundy" and from that tree over eight bushels of fruit were picked. The

photographs were taken early in 1944, about three and a half years after the first soil application was made.

A.—Control. No treatment.

B.—Soil treatment with manganese.

C.—Spray treatment with manganese.

DIAGNOSIS OF MANGANESE DEFICIENCY.

A grower may be able to decide whether or not his trees are suffering from insufficient supplies of manganese by comparing leaves from suspected trees with the illustration (Fig. 1) of the symptoms. A little intervenal yellowing on a few shaded leaves at the bottom of the tree need not be regarded seriously as such leaves can often be found on trees not appreciably affected. If, however, a large proportion of the leaves show the symptoms, the Horticultural Adviser for the district should be consulted for further advice.

Manganese deficient leaves showing intervenal yellowing are usually of normal size and should not be confused with the small partially yellowed leaves which appear on "dieback" shoots on many trees. Such small leaves are not necessarily associated with manganese deficiency at all.

Sufficient data have been accumulated to allow of interpretation of most leaf analyses for manganese. When deemed necessary by the horticultural officer, leaves of suspected trees can be forwarded by him to Perth where confirmatory diagnosis based on leaf analyses can be made.

Selecting Vegetables For Seed Production.

T. C. Dunne, Horticultural Research Officer.

IT is almost impossible to over-emphasize the value of good seed to the grower of vegetables. The production of any intensive vegetable crop entails so much expenditure by way of labour and manures that it is foolhardy to begin with anything but the best available material. Usually the cost of good seed represents only a small proportion of production costs and a lesser quantity of it is needed to ensure sufficient vigorous plants than if poorer quality stock is used. Nevertheless, there are still a number of growers who are content to risk crop failure by the use of seed of mixed or at least doubtful parentage.

For a period during the war years, producers had to contend with the vagaries of seed which in many cases was of poor quality. This was occasioned by losses en route of overseas consignments and the necessity for replacing them with stocks available in a world already suffering from shortage of supplies. At the present time however good quality seed is available, much of it grown in Australia.

Curiously enough, many people still have a prejudice against Australian grown seed. This is hard to understand, particularly in this State where the commercial production of carrots, onions, tomatoes, runner beans and cauliflowers depends to a great extent upon locally grown seed of varieties which were developed within the State.

There are growers, who though normally users of good seed, nevertheless prefer to produce their own seed stocks wherever this is possible. Providing sufficient care is taken this can be well worthwhile. It is well known that many vegetables are particularly responsive to relatively small variations in environmental conditions including climate. For this reason, the nearer the climatic conditions under which a vegetable variety is developed to that where it is intended it shall be grown, the more likelihood there is of obtaining regularly successful crops.

If a beginning is made with vegetables of reasonable quality it is often surprising how quickly improvement can be brought about by intelligent selection. As a guide to those interested growers who are willing to give the necessary attention to seed production, a few reminders for the selection of vegetables for this purpose are given below. Only those vegetables have been dealt with in connection with which improvement might be most easily effected.

CABBAGE.

Select cabbages of the actual size and shape desired but select them all at the one time. If plants are selected over a prolonged period from the same crop, a line of seed is likely to be developed which will show considerable variation in the time taken by the cabbages to mature. Strictly avoid any plants showing signs of disease.

For the initiation of flowering exposure to cooler weather than normally occurs in the metropolitan vegetable growing area is needed. Where the climate is too warm, successful results may be obtained by placing either the stumps or the complete cabbages in cool store (about 8 weeks at 40°F.). Under such conditions, the heads may rot badly but this does not prevent seed production. Transplanting may be done from June to August.

CARROT.

Carrots should be selected for size, good colour, a small, well coloured core, good internal texture, and for flavour. The internal factors can be gauged by cutting about one inch from the bottom of the root. This does not interfere with subsequent growth and may be an advantage when replanting long roots.

In this State, the local varieties show resistance to carrot virus disease but some plants may be affected. For this reason avoid any carrots showing yellowing or malformation of the tops.

Transplanting is done during July and August.

ONIONS.

A large number of growers produce their own onion seed and generally high yielding lines of the both white and brown types of Spearwood Globe are to be found. Many onions however are not inherently good keepers and improvement in this respect is needed. Select, from the longest keeping onions, those bulbs satisfactory with respect to size and shape which have the largest number of thick skin layers. Bulbs may be planted out from May onwards.

TOMATOES.

The early and late Wanneroo types generally grown locally have good colour, flavour and carrying capacity. In many cases however the proportion of solid pulp is too small. Do not select individual tomatoes but select from those individual bushes, the fruits of which when cut across, show plenty of pulp without having a hard core. Such fruits will yield smaller quantities of seed but a quality line will result.

BEANS.

Dwarf—

Yields of dwarf beans are too often reduced by mosaic disease which not only is transmitted from plant to plant but which is also carried in the seed. In the seed plot consistently pull out all plants showing any sign of mosaic and then select from the remaining individual plants.

It has been found with beans, both dwarf and runner, that mosaic symptoms may be masked in hot weather. To ensure all diseased plants being recognised it is advisable to get early growth during the cooler months such as occur in the spring.

Runner—

With runner beans, too, mosaic is an important yield reducing factor and its elimination must be thorough. In the seed plot staking each plant separately will help in eliminating disease and in selecting these individual plants with high yielding qualities. Make sure than the beans are well shaped and true to type.

MANURING.

For seed from tomatoes and beans the normal manuring for these crops will be done as a matter of course. For seeding cabbage, carrot, and onion, liberal manuring is needed for, although certain reserves are stored in the stalk, root, or bulb as the case may be, these are mainly carbohydrates. Nitrogen, phosphate and in some cases potash are needed to induce vigorous seed plants which are prerequisites to good crops of healthy seed.

GENERAL.

No selection, however good, will produce results if care is not taken to avoid cross pollination. A list of plants polinating each other has been published previously in this *Journal* (September 1943). A grower should ensure that his selected plants are placed at least ten chains and preferably further from any source of contamination.

Never save seed from cabbages, carrots or onions which have seeded in the vegetable plot of their own volition. By doing so, lines are being propagated which have a tendency to bolt.

It is most inadvisable to collect seeds of beans or tomatoes after the bulk of the crop has been harvested. If this is done, most of the seed will be obtained from the late maturing plants and from plants which produced material unsuitable for market. Collecting seed in such manner ensures a steady decrease in quality from year to year.

Briefly, in selecting vegetables for seed, avoid disease, select uniformly for uniformity, select the best and keep it pure.

Classing the Clip for Auction.

W. L. McGarry, Sheep and Wool Adviser.

WITH the termination of the appraisement scheme and a reversion to the auction system of wool selling during the 1946-47 season some modification of classing becomes necessary in order to ensure maximum returns.

Under the appraisement scheme every lot of wool whether one bale or more received its full appraisement value but under auction conditions previous experience has indicated that the larger the lot the more competition enjoyed.

Under the auction system the quantity of wool in an offered line (quite apart from the quality) is an important factor in its ultimate value under the hammer.

The preference of the buyer for big lines is reflected in the final bid and it is necessary for the grower to remember this when classing and make as big lines as possible.

Small lots of under four bales are known as "Star" lots. These small lots are sold separately from the "Big" lots (four bales and over) which receive more careful examination and enjoy keener competition than the "Stars."

When classing it is important to remember that a high *average* price per pound is more important and means better returns than where one or two bales of picked fleeces are made into a top line and bring a high price. The quantity and value of the top lines is increased with the blending of these one or two bales of picked fleeces through the top lots. A high *average* price is a most important factor from the viewpoint of *actual cash returns* and the aim should therefore be to make top lines as large as possible.

There has been a definite tendency to overclass many clips under the appraisement scheme and the classing out of many one and two bale lines will not prove profitable under the auction system of selling.

It is unnecessary and unprofitable for farmers to endeavour to "sort" their wool. "Woolclassing" only calls for matching whereas sorting of wool can only be done correctly by the trained sorter.

In order to secure the maximum benefits from classing under the auction system of wool selling it is essential to:—

(1) Make as big and as few lines as the number of sheep being shorn will permit.

(2) Keep tender fleeces out of sound lines.

(3) Keep separate any irregular fleeces which do not match with any of the standard lines. These should be placed in bags or mixed bales. Evenness in length is more important than quality (fibre diameter) in Merino Wool.

(4) Skirt fleeces properly. Hard and fast rules cannot be laid down owing to variable seasonal conditions and the degree of skirting must be left to the classer's discretion. Do not overskirt. Heavy skirting, if not warranted, is unprofitable.

(5) Black tipped, fatty, rough or doggy, and rams fleeces should be kept separate.

(6) Do not sex brand on bales, but advise broker of bale numbers of each sex.

The following descriptions are applicable to agricultural and southern clips. It must be remembered, however, that because a description is shown, it does not necessarily follow that every clip has wool to fit this description and it can therefore be eliminated.

SUGGESTED LINES FOR THE CLASSING OF MERINO FLOCKS OF UP TO 500 SHEEP.

AAA COM	Longest, lightest and brightest.
AA COM	Shorter, heavier and less attractive. All out sorts (rough, very fatty, very tender and rams) to be put into bags or mixed bales.
AA PCS	One line, stains removed.
AA BLS	One line, stains removed.
STD PCS	
LKS	
AAA LAMBS	Longest.
AA LAMBS	Shorter.

FLOCKS OF 500-1000 SHEEP AND OVER.

AAA COM	Sound, good length, light condition (fine to medium quality).
AA COM	Sound, Shorter, heavier (fine to medium quality).
BBB	Sound, good length, light to medium condition, strong quality.
AAA FLC	Average length, fine to medium, tender.
AA PCS	Pieces, stains removed.
AA BLS	One line, stains removed.

STD PCS One line, dags removed.
LKS One line, dags removed.
AAA LBS Longest, stains removed.
AA LBS Shorter, stains removed.

In larger clips extra lines may be made where warranted.

COMEBACK AND CROSSBRED FLOCKS OF UP TO 500 SHEEP.

AAA CBK Finest to medium quality.
or
AAA XB

AA CBK Medium to strong quality (outsorts, such as cotty, discoloured and faulty fleeces to be kept separate).
or
AA XB

AA PCS One line, with stains removed.

AA BLS One line, with stains removed.

STD PCS
LKS

CBK LBS Fine quality, stains removed.
XB LBS Medium to strong quality, stains removed.

COMEBACK AND CROSSBRED FLOCKS OF UP TO 500 SHEEP.

AAA CBK Good length, light to medium condition. Fine quality.
or
AAA XB

AA CBK Good length, light to medium condition, medium quality.
or
AA XB

A CBK Shorter, heavier, fine and medium quality.
or
A XB

AAA CBK FLC All tender fleeces.
or
AAA XB FLC

XB All very strong quality fleeces (all cotty, discoloured and very rough fleeces into bags).

AA PCS One line, stains removed.

AA BLS One line, stains removed.

STD PCS One line, dags removed.

LKS One line, dags removed.

CBK LBS Fine.

XBD LBS Medium to strong (short lambs and lamb skirtings into bags).

In larger clips extra lines may be made where warranted.

Suppurative Otitis in Pigs.

C. R. TOOP, Senior Veterinary Surgeon.

SUPPURATIVE Otitis, an inflammatory condition involving the deeper structures of the ear, is commonly met with in young pigs. Affected animals show characteristic symptoms the most prominent of which is the abnormal carriage of the head, which is constantly held on one side, and this may be accompanied by difficulty in maintaning balance and direction.

The disease is usually secondary to infections of the respiratory tract and is most frequently encountered on piggeries where infectious pneumonia and catarrh are prevalent. The infection reaches the ear by way of the Eustachian tube, a narrow passage which leads from the pharynx or throat to the middle ear. When the disease has become established recovery is unlikely to occur and since there is no effective method of treatment the destruction of affected animals becomes necessary.

Since the condition occurs as a complication of diseases of the respiratory tract the adoption of measures for the control of such diseases which will include attention to sanitation, housing and feeding offers the best means for its prevention.

A weaner affected by otitis. Note the abnormal carriage of the head.

SYMPTOMS.

The disease occurs principally amongst young pigs from a few weeks to about four months old, and here it should be noted that such animals are at an age where they are most highly susceptible to pneumonia and associated respiratory infections. which points to a definite association between the two conditions.

The outstanding symptoms is the abnormal carriage of the head which is constantly held on one side the affected ear being depressed and carried at a lower level than the normal one. Sometimes there is a tendency to walk

in circles the animal moving in the direction of the affected ear, i.e., if the right ear is affected the animal will circle to the right. In the more advanced cases the animal has difficulty in maintaining its sense of direction and balance. The gait becomes unsteady and the animal may have difficulty in walking in a straight line often making several attempts before it is able to reach the feeding trough. When driven, an affected pig may fall to the ground, struggling violently before it is able to regain its feet. In the later stages of the disease the animal is quite unable to maintain its equilibrium and cannot remain on its feet at all.

The condition is usually confined to one ear. Sometimes, however, both ears, become affected and although the head may be carried evenly unsteadiness of gait and difficulty in maintaining balance are marked.

Affected animals are usually in poor condition, become stunted and unthrifty, and are never profitable to maintain.

While the disease is largely confined to young pigs it may affect older animals and has occasionally been observed both in baconers and breeding sows.

CAUSE.

The disease is caused by a micro-organism known as Corynebacterium pyogenes. This organism is frequently implicated in infections of the respiratory tract including pneumonia and catarrh of the upper respiratory passages. From the throat or pharynx the infection spreads along the Eustachian tube to the middle ear subsequently extending to the internal ear. Here it sets up an inflammatory reaction accompanied by suppuration or pus formation.

The ear consists of three parts (1) The external ear; a funnel shaped organ which collects the sound waves and conveys them along a narrow canal or meatus to the tympanic membrane or ear-drum, (2) The middle ear which is separated from the external ear by the tympanic membrane and communicates with the pharynx by the Eustachian tube. It contains a chain of small bony structures known as auditory ossicles by means of which the sound vibrations from the tympanic membrane are transmitted to the internal ear, (3) The internal ear. This is a complex structure which in addition to transmitting the sound impressions received from the middle ear to sensory areas in the brain has another important function, viz the maintenance of equilibrium. It is by means of certain structures in the internal ear that an animal is enabled to retain its balance.

The symptoms which occur, i.e, unsteadiness and incoördination of gait and impairment of the sense of balance are directly related to disease of these deeper structures.

POST-MORTEM APPEARANCES.

Externally no abnormalities are usually observed.

Occasionally when rupture of the tympanic membrane has occured a brownish yellow sticky discharge may be noticed exuding into the passage of the external ear. In order to expose the focus of infection a careful dissection is necessary involving the removal of the overlying bony structures by means of a saw or other suitable instrument. When these structures have been removed an accumulation of thick cheesy pus will be observed in the cavity of the middle ear.

TREATMENT AND PREVENTION.

No effective method of treatment is available and since affected pigs remain stunted and unthrifty and recovery is unlikely to occur they are better destroyed as soon as the symptoms have become established. While there is no direct means of preventing the disease it should be recognised that it is usually secondary to infections of the respiratory tract particularly infectious pneumonia. Consequently if it is possbile to control these respiratory diseases then it should be possible to prevent otitis or at all events to greatly reduce the number of cases which are likely to occur. The measures which should be adopted in this connection must include careful attention to sanitation, housing, and feeding, and these will be practiced as a matter of course on all well managed piggeries. These measures were described in some detail in the December, 1945, issue of this *Journal* in an article which appeared under the heading "Infectious Pneumonia of Pigs."

Transport of Poultry to Market.

By E. LOVEGROVE and S. FROOME.

EVERY summer numerous deaths of poultry during transport to market are reported. The loss to the producer is considerable, especially with the present prices obtained for table poultry, and the community is deprived of an appreciable amount of valuable food which could be distributed. An endeavour to reduce this economic loss requires the co-operative effort of the poultry farmer, the Railway Department and the carriers handling the crates from the railway to the markets.

The producer has many points to watch if he wishes to place his birds "forward on rail" in the best possible condition, and ensure that his preparations will maintain suitable environment throughout the journey.

His first consideration should be not to include in the stock he intends to market any weakling which is likely to be trampled on by the more vigorous birds while in the crate. If this second quality stock must be marketed they should be segregated in one crate and allowed more space per bird. In fact, if two or three crates of poultry are to be marketed at the same time, the birds should be graded and crated according to their strength and vigour.

The type of crate used for transport should conform to certain humane and commercial standards. They must be high enough to allow the birds to stand up, be well ventilated, have receptacles for food and water, and allow ample floor space for the number of birds carried. From the commercial point of view the crates should be constructed of light timber to save freight, but well braced to allow the crates to be stacked. The floor should be close boarded, but the sides, ends and tops should be slatted to give plenty of ventilation.

After making investigations, the Railway Department suggested that a suitable crate for rail transport would be 48 inches long by 21 inches wide by 15 inches high to hold 12 to 14 fowls; the weight when filled to be approximately 112 lb. This size and weight appears to be the most convenient for efficient handling by the railway staff. Crates of this type are provided by the firms dealing with table poultry and are forwarded to the producer at his request.

In hot weather the crates should be stored in as cool and shady a spot as possible; if left in the full blaze of the sun the wood becomes warm and adds to the discomfort of the birds immediately they are crated.

The birds should be given a feed of wheat and green feed and have access to plenty of fresh water about two hours before they are crated.

Birds should not be crated before it is absolutely necessary; only the shortest possible time should elapse before they are consigned by rail or picked up by a carrier.

The problem of feed and water in the crates could be simplified if each crate contained a water tin capable of holding the wheat required for the journey. Wheat which has been soaked in water for 24 hours is placed in the tin and water is added until the surface level of the water and wheat are equal. The water absorbed by the wheat during the soaking supplies part of the requirement and the presence of wheat in the water tin prevents spilling and consequent loss of water supply.

From the time the birds are placed in the crates until they arrive at the markets the crate should always be shaded; a few minutes in the hot sun will adversely affect the birds and their chance of arriving at the market in good condition.

Crates should never be overcrowded, but in hot weather the birds should be allowed more space than is required in the winter.

The *Queensland Agricultural Journal* published in January, 1946, the results of experiments conducted on the loss of weight of poultry in transit by rail. The tests were carried out on birds of the heavy breeds and it is reasonable to expect that the proportional loss in the light breeds would be greater. The figures given were as follows:—

Distance.	Average loss per bird.	Per cent. loss per bird.
221 miles (21 hours)	5.99 ozs.	7.0
106 miles	3.0 ozs.	3.3
47 miles	3.2 ozs.	3.95

Other birds were fed and then crated at 6 p.m. and the crates were held on the farm for a number of hours.

Time held.	Average loss per bird.	Per cent. loss per bird.
12 hours	4.19 ozs.	3.84
18 hours	6.87 ozs.	6.47

It will be noted that the loss of weight is from three to seven per cent. according to the length of time the birds remain in the crates, and under adverse travelling conditions the loss would probably be much greater.

Since the advent of price fixing most birds marketed are sold by weight, so it is in the interest of the producer that the loss of weight in transit should be reduced to its minimum by practising the special care and attention suggested.

As mentioned previously the co-operation of the Railway Department is required if a reduction in the number of birds found dead on arrival at the market is to be achieved. Towards the end of 1943 investigation was made

into the cause of the mortality then occurring, and recommendations were made to the Chief Traffic Manager, who stated that the matter was being taken up specially throughout the system, in order to ensure that the best possible results were achieved. He pointed out that very comprehensive instructions were in force on the railways. These instructions are of prime importance to the poultry farmer and are, therefore, published here for his information:—

> "Before any case or crate containing livestock (animals or birds) is received for conveyance, the person accepting must see that the livestock is not overcrowded, that sufficient ventilation is provided for and that provision is made for feeding and watering on long journeys. If these conditions are not complied with the livestock must be refused.
>
> In the case of such traffic picked up at unattended sidings, and the above instructions are not complied with, guards must put the package out at the nearest station so that the contents can be transferred to a suitable box or crate at the expense of the owner.
>
> When poultry has to travel by rail 50 miles or over, water must be placed in coops, etc."

Representation is being made to the Chief Traffic Manager to emphasise the necessity of these instructions to his staff and that in the building of furthur rolling stock consideration be given to special louvred vans for poultry. It is also suggested that louvred vans be made available on stated trains for the transport of poultry only.

The last link in the chain are the carriers, and to satisfactorily conclude the transport they should be present and be able to obtain delivery of the crates of birds soon after the arrival of the trains.

It would appear that there are no unsurmountable difficulties to the reduction of the mortality which occurs in the transport of poultry to market, but, rather, that attention to detail on the part of the poultry farmer, coupled with the ready co-operation of the Railway Department and the carriers, will produce the desired result.

Muresk Egg Laying Trial No. 16

1945-46.

GENERAL REVIEW.

By K. M. COWIN, Poultry Instructor, Muresk Agricultural College.

The sixteenth test of the Muresk Egg Laying Trial terminated on 2nd March 1946.

Rainfall recorded at Muresk during the period of the trial is shown in the following table:—

1945.	Pts.	No. wet days.
April	29	3
May	172	12
June	983	24
July	213	19
August	429	27
September	203	15
October	18	4
November	67	3
December	13	2

For the period of the trial in 1946 there were no wet days so no rainfall was recorded.

The following table shows the number of days with minimum temperature of 35° and under, and maximum temperature of 95° and over at Muresk during the period of the trial.

1945.	No. of days min. 35° and under.	No. of days max. 95° and over.	Hottest day of the month.
April	-	1	98.0°
May	-	-	85.5°
June	-	-	73.0°
July	2	-	63.0°
August	-	-	68.0°
September	4	-	76.0°
October	1	-	89.0°
November	-	2	98.0°
December	-	9	100.6°
1946.			
January	-	6	100.6°
February	-	5	106.8°
March (2 days) ..	-	2	104.0°

SUMMARY OF THE RESULTS OF VARIOUS SECTIONS 1945-46.

Analyses of breed results are shown hereunder:—

Sec.	Breed.	No. of Birds.	Per cent. of Total Entries.	No. of Birds Died.	Per cent. Deaths in Sect.	No. Birds completed Test.	Production of 1st Grade Eggs.		Production of 2nd Grade Eggs.		Total Eggs Produced.	
							No.	Av. per Bird.	No.	Av. per Bird.	No.	Av. per Bird.
A.	White Leghorn	240	57·14	11	4·58	229	30,584	127·43	8,639	35·99	39,223	163·42
B.	Australorp	150	35·72	13	8·66	137	22,770	151·86	4,806	32·04	27,576	183·84
B.	Chinese Langshan	6	1·43	*nil*	*nil*	6	714	119·00	150	25·00	864	144·00
C.	Rhode Island Red	24	5·71	1	4·16	23	2,372	98·83	610	25·41	2,982	124·25
Total All Sections		420	100·0	25	5·95	395	56,440	134·38	14,205	33·82	70,645	168·20

EGG PRODUCTION.

In addition to low egg production, the percentage of second grade eggs was very disappointing. The main contributing factor was the short and irregular supply of meat-meal available for this trial.

Grading of Eggs for Weight.

All eggs were weighed in accordance with Regulation No. 2 which states:—

"First Grade.—During the first two months of the trial a first grade egg shall weigh not less than 1¾ ozs., thereafter during the remainder of the trial a first grade egg shall weigh not less than 2 ozs."

"Second Grade.—The minimum weight of a second grade egg shall be not more than ¼ oz. less than a first grade egg. Second grade eggs will be recorded but not counted."

The following table shows the various groups of egg production in the last five trials. (All eggs counted.)

Trial.	Producing 100 and under.		Producing 101–150 eggs.		Producing 151–200 eggs.		Producing 201–250 eggs.		Producing 251 and over.	
	No. Birds.	%	No. Birds.	%	No. Birds.	%	No. Birds.	%	No. Birds.	%
1941–42	31	9·06	40	11·70	108	31·58	125	36·55	38	11·11
1942–43	32	9·36	35	10·23	77	22·51	155	45·32	43	12·58
1943–44	39	9·28	67	15·95	135	32·14	136	32·38	43	10·23
1944–45	20	5·38	50	13·44	140	37·63	139	37·36	23	6·19
1945–46	37	8·81	92	21·90	190	45·24	100	23·81	1	·24

The following table shows the various groups of egg production in the separate sections. (All eggs counted.)

Sec.	Breed.	No. of Birds in Sect.	Producing 100 eggs and under.		Producing 101–150 eggs.		Producing 151–200 eggs.		Producing 201–250 eggs.		Producing 251 eggs and over.	
			No. Birds.	%	No. Birds.	%	No. Birds.	%	No. Birds.	%	No. Birds.	%
A.	White Leghorn	240	25	10·42	58	24·16	102	42·50	55	22·92	....	...
B.	Chinese Langshan	6	....	....	4	66·66	1	16·66	1	16·66	....	...
B.	Australorp	150	8	5·33	17	11·33	80	53·33	44	29·33	1	·66
C.	Rhode Island Red	24	4	16·66	13	54·16	7	29·16	....	....	....	....

WINTER TEST.

The first four months of the trial (1st April to 31st July '45) is known as the Winter Test. The following particulars show the winners and number of eggs laid.

	First grade eggs.	Second grade eggs.	Highest individual bird in team.
Section "A."			
1st R. Harrison (2)	362	41	72
2nd I. Schwarz	357	35	74
3rd H. B. Chalmer	341	69	78
Section "B."			
1st R. Harrison (2)	474	21	94
2nd Mrs. M. H. Dadley (1) ..	455	11	87
3rd M. H. Dadley	451	4	99
Section "C."			
1st M. Miller	322	38	67
2nd A. Machlin	224	52	79

GOVERNMENT STANDARD CERTIFICATE.

Standard Certificates and sealed copper bands are awarded to birds that lay 200 first grade eggs or over during the period covered by the trial.

The following table shows the number and percentage of certificate winners for all tests since the 1936-37 trial.

Trial.	No. of birds in trial.	No. of birds qualified.	Percentage that qualified.
1936-37	249	69	27.71
1937-38	240	75	31.25
1938-39	294	78	26.53
1939-40	336	68	20.23
1940-41	336	90	26.78
1941-42	342	124	36.22
1942-43	342	162	47.36
1943-44	420	140	33.33
1944-45	372	119	31.98
1945-46	420	41	9.76

Standard Certificate Winners, 1945-46.

White Leghorn.

Owner.	Bird No.	Copper band No.
Max Stocker	27	1
C. Rodgers	79	2
C. Rodgers	81	3
C. Rodgers	85	4
C. Rodgers	89	5
P. Harrison	5	6
Max Stocker	21	7
Mrs. McFadden	33	8
Mrs. J. E. Smith	70	9
Mrs. J. E. Smith	71	10
G. A. Johnson	105	11
H. P. Chalmer	123	12
H. P. Chalmer	124	13
Mrs. H. P. Chalmer	130	14
G. A. Osbourn	169	15
Mrs. W. R. Lister	190	16
Mrs. W. R. Lister	192	17
W. R. Webb	204	18
W. R. Webb	205	19
E. E. Price	220	20
Mrs. E. E. Price	234	21

Chinese Langshan.

Thos. Parker	5	66

Australorp.

H. R. Pearson	13	68
W. G. Hall	25	79
W. G. Hall	30	80
F. T. Whitfield	31	82
F. T. Whitfield	36	83
Mrs. F. T. Whitfield	45	84
W. R. Lister	55	85
A. P. Caporn	62	86
A. R. Caporn	64	87

Standard Certificate Winners, 1945-46—continued.

Australorp—continued.

Owner.	Bird No.	Copper band No.
P. Harrison	75	88
A. Machlin	80	90
E. E. Price	90	91
Mrs. E. E. Price	94	92
T. Gent	99	93
G. Barker	112	94
M. H. Dadley	120	95
Mrs. M. H. Dadley	127	96
V. J. Dadley	134	97
Miss J. M. Dadley	139	98

FINAL LEADING SCORES

Competitor.	First grade eggs.	Second grade eggs.	Score of highest bird in team.
Section "A"—White Leghorns.			
1st Mrs. McFadden	1016	106	226
2nd C. Rodgers (2)	1010	45	204
3rd R. Harrison (2)	998	212	197
Section "B"—Australorps.			
1st Mrs. M. H. Dadley (2) ..	1119	66	225
2nd Mrs. F. T. Whitfield ..	1113	45	223
3rd F. T. Whitfield (1) ..	1063	129	223
Section "B"—Chinese Langshan.			
Thos. Parker	714	159	203
Section "C"—Rhode Island Reds.			
1st M. Miller	699	182	176
2nd A. Machlin	605	118	169
3rd G. E. Price	588	104	124

At a social arranged by the Committee of Management in the Shell Oil Co's. Theatrette and Social Rooms, St. George's Terrace, Perth, on 9th May 1946, the Hon. J. T. Tonkin, Minister for Agriculture presented the trophies to the successful competitors in the 1945-46 Muresk Egg Laying Trial.

Trophy List showing donors and successful competitors.

Prize List.

Champion Certificate—W.A. Produce Trophy. Score.

Owner: Mrs. M. H. Dadley—

First grade 1,119
Second grade 66

Team of Six Birds—Section "A" Light Breeds—White Leghorns.

First prize (Westralian Farmers and Eggoleen Cups, J. Freecorn and Westralian Farmers Trophy. Owner: Mrs. McFadden—

First grade 1,016
Second grade 106

Second prize (L & M. Cullen Trophy). Owner: C. Rodgers— Score.

First grade	1,010
Second grade	45

Third prize (Boans Trophy). Owner: R. Harrison—

First grade	998
Second grade	212

Team of Six Birds—Section "B" Heavy Breeds—Australorps.

First prize (Associated Agents Cup, J. Inkpen and L. J. Kendall Trophy). Owner: Mrs. M. H. Dadley.

First grade	1,119
Second grade	66

Second prize (Haynes & Clements Trophy). Owner: Mrs. F. T. Whitfield—

First grade	1,113
Second grade	45

Third prize (F. W. Wright Trophy). Owner: Mr. F. T. Whitfield—

First grade	1,063
Second grade	129

Team of Six Birds—Section "C" Medium Heavy Breeds—Rhode Island Reds.

First prize (Dunklings Cup, R. B. Young and J. Lori Trophy). Owner: Mr. M. Miller—

First grade	699
Second grade	182

Second prize (Associated Agents and J. Goss Trophy). Owner: Mr. A. Machlin—

First grade	605
Second grade	118

Winter Test (*from* 1*st April to* 31*st July*).

Section "A" Light Breeds.

First prize (C. A. Kirkby and J. Scanlon Trophy). Owner: R. Harrison—

First grade	362
Second grade	41

Section "B" Heavy Breeds.

First prize (M. H. Dadley and A. R. Caporn Trophy). Owner: R. Harrison—

First grade	474
Second grade	21

Section "C" Medium Heavy Breeds.

First prize (Mrs. S. Giles Trophy). Owner: M. Miller—

First grade	322
Second grade	38

Summer Test (from 1st December to 2nd March). Score.

Section "A" Light Breeds.

First prize (Western Ice Co. Cup and Deputy Controller Egg Supplies Trophy). Owner: Mrs. McFadden—

First grade	285
Second grade	35

Section "B" Heavy Breeds.

First prize (Western Ice Co. Cup and Thomas & Co. Trophy). Owner: F. T. Whitfield—

First grade	260
Second grade	38

Section "C" Medium Heavy Breeds.

First prize (Western Ice Co. Cup and R. Piercey Trophy). Owner: G. E. Price—

First grade	131
Second grade	34

Individual Birds.

Section "A" Light Breeds.

First prize (Macfarlane Cup and Multiplo Trophy). Owner: Mr. G. A. Johnson, Bird No. 105—

First grade	234
Second grade	5

Second prize (York Flour Mills Trophy). Owner: C. Rodgers, Bird No. 81—

First grade	231
Second grade	2

Section "B" Heavy Breeds.

First prize (Baird Cup and M. Bell Trophy). Owner: Mrs. E. E. Price, Bird No. 94—

First grade	235
Second grade	6

Second prize (Malloch Bros. and J. Banfield Trophy). Owner: M. H. Dadley, Bird No. 120—

First grade	233
Second grade	3

Section "C" Medium Heavy Breeds.

First prize (Enston Cup and W. Hoops and W. Southern Trophy). Owner: M. Miller, Bird No. 26—

First grade	176
Second grade	15

First Bird to Lay 200 First Grade Eggs.

Section "A" (Flint and Eldridge Trophy). Owner: G. A. Johnson, Bird No. 105, 4th January, 1946.

Section "B" (M. A. Gordon Trophy). Owner: Mrs. E. E. Price, Bird No. 94, 3rd January, 1946.

Section "C"—Nil.

Special Prizes.

Teams of Six Birds judged for type by Messrs. Love and Lethbridge.

Section "A" Light Breeds.

First prize (W. Lister and T. Newby Trophy). Owner C. Rodgers, Pens 79-84.

Second prize (A. Richards Trophy). Owner: R. G. Gent, Pens 43-48.

Section "B" Heavy Breeds.

First prize (Carbarn, Mulberry and McLean Trophy). Owner: Mrs. F. T. Whitfield, Pens 43-48.

Second prize (Foy & Gibson and W. H. Milne Trophy). Owner: Mrs. M. H. Dadley, Pens 121-128.

Section "C" Medium Heavy Breeds.

First prize (Barrow, Linton and S. Froome Trophy). Owner: M. Miller, Pens 25-30.

Team Laying Lowest Percentage Second Grade Eggs; minimum lay 1,000 *eggs.*

D. H. Doust and Harrold and Murray Trophies. Owner: Mrs. F. T. Whitfield (Australorp)—

	Score.
First grade	1,113
Second grade	45

Bird Laying Longest Sequence First Grade Eggs.

J. & W. Bateman Trophy. Owner: G. Barker, Australorp No. 108; sequence 58.

Bacterial Canker of Tomatoes.

W. P. Cass Smith, Plant Pathologist.
O. M. Goss, Assistant Plant Pathologist.

BACTERIAL canker of tomatoes was first recorded in Western Australia in December, 1945, in the Wanneroo and Balcatta areas. Subsequently it was also identified from the Denmark and Coogee districts.

The disease was apparently introduced with seed stocks imported from the Eastern States of Australia where it has occurred for some years, and the variety Tatura is particularly suspect, as three badly infected and widely separated crops of this variety originated from seed which was traced to the same source.

Bacterial canker is recognised as a very serious disease in many countries of the world, and in this State it has also caused heavy losses in some affected crops, amounting in two cases to almost total destruction. It appears to be more serious in staked and pruned, than in unstaked crops, and also in crops grown under sprinklers, rather than on moist land or furrow irrigated. Not only does the disease affect the market quality of the fruit, but by causing premature death of plants it seriously reduces the yield also. Steps have already been taken with the object of preventing the spread of the disease in affected areas, and reducing other sources of infection, but all tomato growers are advised to familiarise themselves with the symptoms of bacterial canker and the methods whereby it may be avoided.

Fortunately in this State most commercial growers save their own seed, and this practice should help to prevent a widespread establishment and assist in the control of this serious seed-borne disease.

Fig. 1.—Single leaf showing early stages of disease. Note uprolling of leaflets and slight marginal withering. Note also that a single leaflet has shrivelled before the remainder.

Symptoms and Effects.

Typically the disease spreads from the base of the plant upwards causing the lower leaves to die progressively up the stem. Death of the leaves is preceded by a gradual marginal withering and upwards rolling of the leaflets (Fig. 1) frequently confined at first to single leaflets, or the leaflets on one side of the leaves only which shrivel up before the remainder (Figs. 1 and 2). Eventually the whole leaf shrivels and dies, and hangs down, but it does not fall readily from the plant, for the leaf stalk remains erect and stiff and only gradually withers (Fig. 3). If such infected leaves are broken from the stem a discolouration of the water conducting tissue is visible, yellow at an early stage and brown at a more advanced stage of the disease.

When cut in section the stem shows definite browning of the water conducting tissues extending into the pith which also becomes yellowed and finally dark brown. There is a tendency to mealiness and to the formation of pockets in the pith which finally becomes hollowed out. Browning and breakdown of the pith is more definite at the nodes, and there is little evidence of the disease in the below-ground parts of the plant (Fig. 4, a, b, and c).

During wet weather or when overhead sprinklers are used, whitish, round to oval, spots often appear on stems (Fig 5a), leaf stalks, and sometimes on the leaves also. When the fruit develops it may also show this external spotting, white at first, then with a brownish and usually cracked centre (so-called bird's eye spotting) (Fig 6). This symptom, when it occurs, is absolutely diagnostic of the disease.

Fig. 2.—Single leaf (still attached to plant) at later stage of the disease. Note shrivelled leaflets on one side of leaf only, and marginal withering and uprolling of remainder.

In the later stages of disease development, the stems show elongated whitish patches which may split longitudinally, giving cankers, although under our conditions canker formation appears to be rare (Fig. 7). Sometimes the small white spots on the stem (Fig. 5a) may split and develop into secondary cankers.

Fig. 3.—Young plant inoculated by means of needle prick with *A. michiganense* (three weeks after inoculation). Note withered leaves which hang down from the erect leaf stalks.

The fruit often drops prematurely and may show a browning beneath the calyx lobes. In badly affected fruits the browning extends internally resulting in brownish discoloured areas and brown water conducting strands (Fig. 5b).

Superficially bacterial canker resembles fusarium wilt but the one sided withering of the leaves, the absence of leaf yellowing, the formation of pockets in the pith, and the fruit spots and stem cankers when present, serve to distinguish it from the latter trouble.

Development of the Disease.

The disease is caused by a bacterial parasite *Aplanobacter michiganense* and these minute organisms are generally introduced into new areas by means of infected seed or seedlings.

The bacteria invade the fruit of diseased plants through the water conducting strands, with the result that the seeds become infected. Fruit invaded at an early stage may show internal discolouration (Fig. 5b) but it should be noted that fruit invaded at a later stage of development may ripen normally, and show little or no internal evidence of the disease to the naked eye.

Fig. 4.—Longitudinal sections of stems.
(a) Early stage, showing browned water-conducting strands in stem and leaf stalk.
(b) Later stage showing in addition slight discolouration.
(c) Final stage with pith very dark and tending to break down and form cavities. N.B.—Widening of discolouration at nodes.

However, the seeds saved from such fruit may give rise to the disease when planted.

When infected plants are present in either seed-bed or field, the disease may be spread in any of the following ways:—

(a) Handling of seedlings during transplanting, if a diseased seedling is handled prior to healthy ones.

(b) During pruning. This is a most important means of spread, for Ark (1944)[1] in America was able to transmit the disease to over 30 consecutive plants after cutting one diseased plant with the pruning knife.

(c) In the splash from sprinklers, rain, etc., especially if wounds are present on the plant. (This also gives rise to the surface fruit spots which make fruit unsightly and lower its market value.)

Fig. 5.

(a) Portion of stem and attached fruit showing external whitish spots caused by splashing with water containing the canker organism.

(b) Longitudinal section of tomato fruit showing browning below calyx lobes, brown discoloured areas in pith and browned water-conducting strands due to presence of the disease.

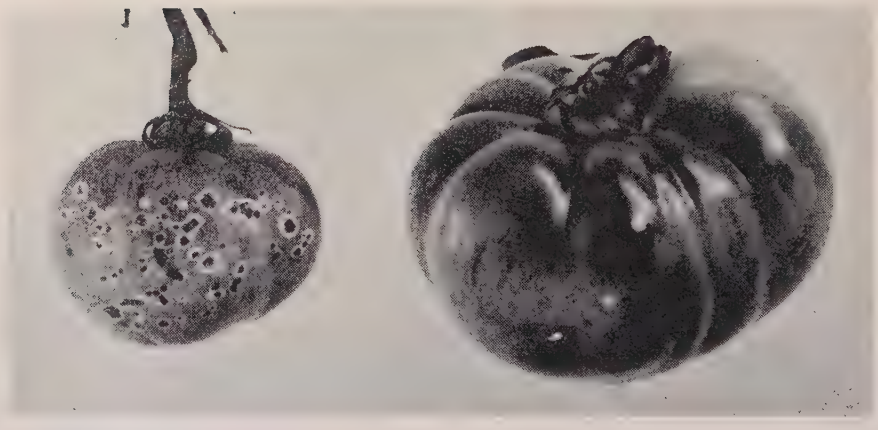


Fig. 6.—Fruit showing "bird's eye" spotting due to external infections with the canker organism. On left: badly infected fruit. Note white haloes and dark centres of spots On right: early stage of spot.

Once the disease has occurred in an area, either seed-bed or field soil, it may remain in the soil and infect the next crop of tomatoes.

Control.

(1) Seed should be saved only from crops entirely free of canker. This is most important as the primary spread of the disease is due to infected seed.

(2) Seed should be extracted by fermenting the pulped fruit without water for four days in a cool shady place. The fermenting material should be stirred night and morning to submerge pulp floating on the surface.

(3) Purchased seed or seed unavoidably saved from crops in which even traces of canker had been noticed should be disinfected either by steeping for 25 minutes in water maintained at 122° F. or in 0.6 per cent. glacial acetic acid solution (one fluid ounce of acid in a gallon of water) for 24 hours. The hot water treatment is preferred as it is said to be effective not only against bacterial canker, but also against all other seed-borne diseases of tomato(2), including early blight or target spot, fusarium and bacterial wilts. After treatment, seed should be dried thoroughly and dusted before planting, with spergon (tetroc) or one of the organic mercury dusts, e.g., ceresan, agrosan, etc. This treatment guards against damping off and often results in improved germination.

Fig. 7.

Stem of diseased plant showing elongated, light, sunken patches, which may split to form cankers, as in specimen. Canker formation appears to be rare under our conditions.

(4) Diseased crop remains should be burnt, not ploughed in, as the organism can live for at least two years in the soil.

(5) Once the disease has occurred do not crop land with tomatoes for at least three years.

(6) Seed-bed sites should be changed at each planting, and if permanent wooden frames or seed boxes are used, these should be disinfected by drenching with two per cent. formalin (one gallon commercial formalin in 49 gallons of water) or two per cent. bluestone solution (one pound in five gallons of water).

(7) During pruning, if a diseased plant is handled or cut, the hands and knife should be thoroughly washed in soapy water before other healthy plants are dealt with.

(8) If a diseased plant is discovered during pruning, etc., rogue it out and burn it as it serves as a source of infection to neighbouring plants during splash from sprinklers, rain, etc.

(Full details of the simple, home-made apparatus required for carrying out a hot water seed treatment are given in advisory leaflet 747 obtainable free of charge from the Department of Agriculture.)

(1) ARK, P.A.—Studies on Bacterial Canker of Tomato. *Phytopathology*, Vol. 34, No 4, April, 1944.
(2) U.S.D.A. *Farmers' Bulletin*, No. 1934 (1943)—Tomato Diseases.

EXPERIMENTAL.

The Organism.

The casual organism is most readily isolated from the petioles of diseased leaves, especially those showing the early stages of the disease. The method found most satisfactory is aseptic plating of expressed sap. Of the standard laboratory media tried the organism grows most readily on Potato-Dextrose Agar or Potato-Dextrose-Peptone Agar.

The bacteria are very short rods with rounded ends occurring singly or in pairs. They are gram positive and non-motile, and no evidence of spores or capsules was seen.

On *Meat Extract Agar* the colonies are small, circular, smooth, slow-growing (four to five days to become visible at a temperature of about 27° C.) pale yellow becoming darker with age. On *Potato-Dextrose Agar* growth is more rapid and cream-yellow in colour. In *Nutrient Broth* a slight turbidity is developed but no pellicle or rim is formed. On *Steamed Potato* a small amount of yellow slime develops. *Gelatine Stab*—there is a very slow growth which sinks slightly into medium but shows no sign of liquefaction even after six weeks. *Litmus Milk*—a soft curd is formed in about eight days. Later a yellow rim develops followed by a complete pellicle. No peptonisation occurs. The litmus is reduced. There is no growth in *Cohn's* and *Fermi's* solutions. Starch is not hydrolysed, nitrates are not reduced and there is no production of indol. No acid and no gas are produced from sucrose dextrose, mannite, maltose, lactose, salicin or glycerol for several weeks but after about one month there is a slight acid production from sucrose, maltose and salicin.

The above description agrees very closely with that given for *Aplanabacter michiganense*, except that it failed to liquefy gelatine.

Inoculation tests were done into healthy tomato plants using needle pricks into the basal stem region—control plants being pricked similarly with a sterile needle. In 12 days the inoculated plants showed definite symptoms of disease—the lower leaves wilting and tending to wither (Fig. 3). In 32 days the plants were dead. Isolations from petioles gave an organism similar in all respects to the one used for inoculation. The control plants remained healthy.

This disease is known to be seed borne but great difficulty has been experienced in actually isolating it from the seed by cultural methods. From seed collected by Mr. Russell of Balcatta from apparently diseased plants numerous plates were made using the following techniques.

(1) Direct platings of seed on Meat Extract Agar.
(2) Seed washed in sterile water and plated.
(3) Seed surface sterilised with alcohol (one minute) and plated.
(4) Seed surface sterilised with $HgCl_2$ 1/1000 for one minute, and washed in sterile water.

None of these techniques, however, yielded the organism—in the case of 1 and 2 probably because of its slow growth compared with other saprophytic organisms present on the seed, and in 3 and 4 because the seed, in this case, was probably only surface contaminated and the organisms were therefore killed out.

Later, seed was extracted by the authors from fruits which were first proved to contain the disease both in the pulp and in the vascular supply and this was saved for further experiment. From this seed the organisms were obtained by direct plating both on Meat Extract Agar, Potato-Dextrose Agar and Potato-Dextrose Agar plus peptone. It is, however, realised that such highly infected samples are rare, so experiments are in progress to determine the age at which it is first possible to demonstrate the disease in seedlings.

Experiments on Seed Treatments.

In an effort to determine the most effective seed treatment control measures for this disease, preliminary experiments have been carried out with hot water, acetic acid dip and long fermentation in the extraction of seed. (See control measures (2) and (3) pages 152 and 153.)

1. *Hot Water Treatment.*—The following experiments were performed to try and ascertain (a) the effect of water temperature and duration of exposure, on the organism and seed germination, (b) the effectiveness or otherwise of the standard hot water treatment (25 minutes at 50° C.) (2). Suspensions of the bacteria in sterile water were subjected to varying temperatures for varying periods, as set out in the table below, and at the same time samples of seed were immersed in water at the same temperatures and for similar periods. In each case the test tube of water to which the organism was added was first raised to the required temperature and held constant in a water bath for the required time. A loopful of of the suspension was subsequently smeared over the surface of agar in each case.

Water Temperature.	Period mins.	No. of Colonies on Plate.	Seed Germination. %
49°C.	15	6 colonies	95
	20	2 colonies	96
	25	Nil	97
	30	Nil	97
	35	Nil	98
50°C.	15	Nil	97
	20	Nil	97
	25	Nil	96
	30	Nil	96
51°C.	15	Nil	99
	20	Nil	98
	25	Nil	99
	30	Nil	99
55°C.	25	Nil	98
Control Untreated Seed	...	...	98

It therefore appears that exposure to water at a temperature of 50° C. or above for these periods is effective in killing out the canker organism, at least when in water suspension, and that these treatments did not impair the germination of the seed.

In a number of tests conducted later it was shown that neither is the germination of good seed samples, nor the subsequent growth to maturity of several popular varieties impaired by the standard hot water treatment.

Pot experiments also were carried out to determine the effectiveness of the standard hot water seed treatment, using a sample of diseased seed—

(1) Were untreated.

(2) Were treated with hot water.

(3) Were treated with hot water and then surface contaminated with a pure culture of *A. michiganense.*

After 14 days, counts were made of the number of germinated seeds, giving the following results 15:16:12 respectively—four days later it was 16:16:9. Presumably the external contamination of the seed had killed off three of the young seedlings in pot 3. After three months the plants in pot 3 were showing definite signs of canker and were dying off (the organism was re-isolated). By three and a half months there were only five plants left and these were all showing symptoms of disease. After three and a half months, five of the plants in pot 1 were showing canker symptoms and the organism was isolated from these. No pruning was done at any stage and no transplanting. No external cankers developed and no surface spotting—the most obvious symptom being the wilting, rolling and withering of the leaves. The plants in pot 2 still showed no evidence of canker but were becoming unthrifty due to crowding and bad weather conditions.

2. *Acetic Acid* 0.6 *per cent. for* 24 *hours.*—Germination tests on seed samples.

	Untreated.	Acetic Acid.	Hot Water.
	%	%	%
(1)	60	9	41
(2)	98	92	97

N.B.—(1) was a poor sample of seed giving a low germination even when untreated—but with good seed samples neither acetic acid nor hot water injures the germination.

3. *Long Fermentation.*—Germination 92 per cent.

Field experiments have shown that there is no harmful effect on subsequent growth following any of these treatments, but preference is given to the hot water treatment as it is more effective against internally born canker disease and also against other seed borne diseases.

Other Hosts.

To determine whether other related plants were susceptible to infection with canker, inoculations were done to tomato, Solanum nigrum (four plants inoculated in all) and potato creeper. The tomato was the only plant which developed the disease.

The Main Honey Producing Flora of Western Australia.

L. BLAIR, Government Apiculturist.

THIS leaflet is written with the object of assisting the younger apiarists in the State and in response to the growing number of inquiries in regard to the different flowering periods of the main honey bearing eucalypts. These trees are the main source of honey gathered in W.A. and their flowering periods and bud development vary to a marked degree. A general knowledge of their habits should be a help to the young apiarist in mapping out his inspection of areas prior to moving or migrating bees to the different districts to take advantage of the honey flows as they occur. Seasonal conditions to a great extent govern the secretion of nectar, and often a genus of plants or trees may have a good showing of bloom with very little or no nectar. Then again it may have a fair secretion of nectar and very little or no pollen. The pollen may be very dry and will be blown off by a light breeze and the bees may not be able to gather sufficient pollen to stimulate brood rearing.

The majority of districts that have any cleared portion of land throughout W.A. contain a liberal quantity of Cape Weed (*Cryptostemma calendulaceum*). This plant, an introduced one from South Africa, being one of the first main flowers in the spring, contains, generally, a liberal quantity of both nectar and pollen; blooms July to October, varying somewhat in different districts; and is the main factor in building up the strength of the hives after the winter months. Prior to this blooming the Flooded Gum is practically the first eucalypt to bloom. Very often this tree blooms in very wet weather and the bees do not obtain the full benefit from this species.

Flooded Gum.

YORK GUM (*Eucalyptus redis* Endl.).—This species blooms in the early summer and is a regular annual flowering variety being naturally better some seasons than others. The bud development is about nine to ten months. The honey is only a second grade. This eucalypt grows on good agricultural land and a large area has been cleared for cereal cropping.

The next eucalypt to follow is the Coastal Jarrah (*E. marginata*). The blooming of this eucalypt varies in different districts as much as six weeks. However, the general period for blooming in the coastal areas starts about the end

of October to December, and later in the hills and on heavier soils. This honey is a dense honey and has a nice "nutty" flavour in the coastal districts and tends to become much darker in the heavier soils, contains a larger proportion of *levulose* and seldom candies. Bud development is approximately nine to ten months.

Coastal Jarrah in flower with seed pods showing on bottom of spray. Note the perforation of the leaves caused by the parasite moth (Tinea spp.).

The next to flower is the Wandoo (*E. redunca* var. *elata* Bth) or Summer White Gum. This eucalypt, in my estimation, is one of the best honey producing trees in Australia, being very reliable and a prolific source of nectar with an ample supply of pollen. The flowering period extends from three to five months. The honey is of first class quality, varying in colour from amber to light amber, good density, granulation of medium grain and light creamy colour. This species starts flowering in November and December and finishes off about March, varying somewhat in different districts and localities. The White Gum flowers sometimes two and three years in rotation, then most likely will have a two years' spell during which period the new growth with buds will be developing, the development period of these buds covers a period of two years. It is very necessary for apiarists to familiarize themselves with the appearance of these buds just

prior to their coming into bloom. At this stage the bud caps assume a deep reddish brown colour. This colour is pretty general with the majority of the eucalypt caps prior to flowering. Particular attention should be paid to this characteristic as a mistake in migrating apiaries to a district before the buds are ready to flower would involve the apiarist in a great deal of unnecessary expense and would entail a further shift to pastures new.

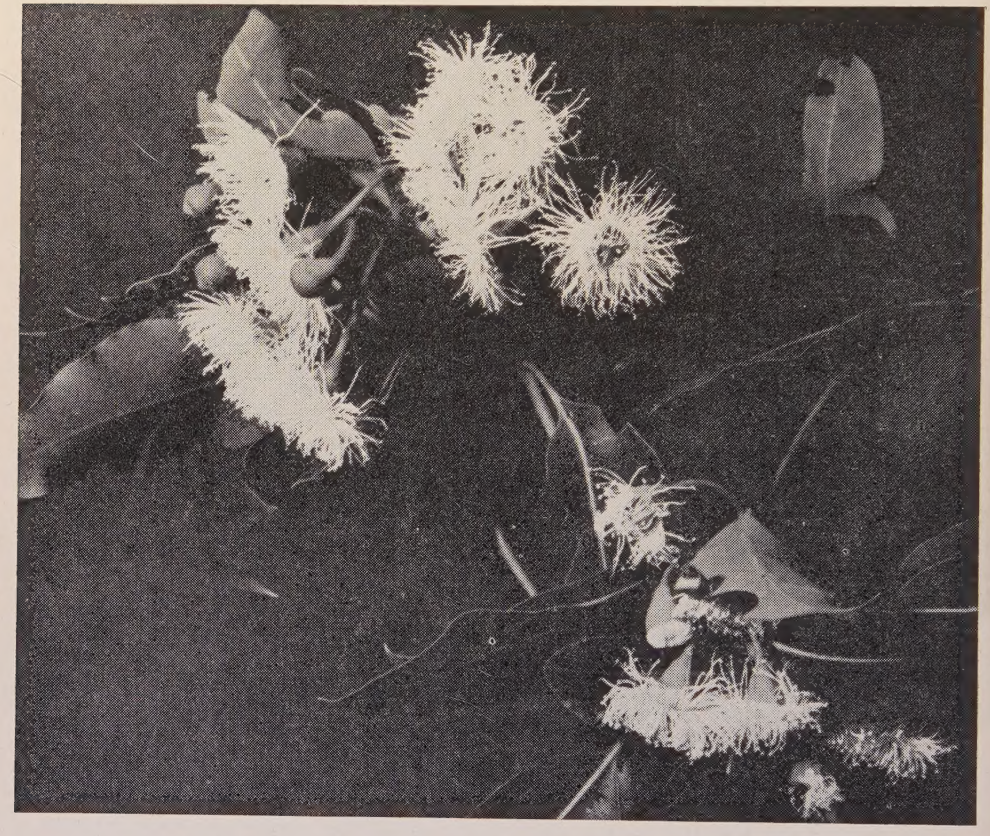
Winter White Gum.—A heavy honey producer.

WINTER WHITE GUM.—A eucalypt indistinguishable from (*E. redunca* var. *elata* Bth) but has a different flowering period. The early trees begin blooming about March and often continue right through the winter months. This variety grows mainly on the foothills of the Darling Range extending north beyond Moora. It is a good heavy yielder of a first class honey with a fairly even grained candy. The bud development period is two years, the same as the Summer White Gum.

The POWDER BARK WANDOO (*E. accedens*).—This tree grows in the same country as the White Gum and, to the casual observer, could be mistaken for White Gum. On closer investigation there are a great number of different features by which it can be recognised. First the appearance of the bark, which has a salmon colour and if rubbed it leaves a quantity of light coloured powder on the hand. The leaves are wider and the buds are of a different shape. This species comes into flower just before the Summer White Gum bloom finishes.

This tree only blooms about once in a four-yearly cycle. The honey is of first-class quality, good flavour, and density, and a very fine grained candy when crystalised. The flow of nectar varies considerably in different districts and cuts out as soon as the wet season approaches.

MARRI or RED GUM (*E. calophylla* R. Br.).—This eucalypt is a very striking tree when in bloom and develops its buds and flowers within three months. With weather and soil conditions being favourable it is a good yielder



Marri or Red Gum.—A heavy honey producer when seasonal conditions are favourable. New growth buds and flowers develop within three months.

of nectar and pollen, in a favourable season the nectar will fill the flower cups and drip nectar from them. The conditions for a good flow from this species are a damp subsoil with humid weather or heavy dewy nights, and absence of seed vessels in great numbers being ripened on the tree from a previous setting. The period of flowering extends from February to March and April generally, and varies somewhat as to length of flow according to seasonal conditions. This honey also is considered of first class quality but varies somewhat according to the district, the heavier soils as a rule producing the better honey. Red Gum or Marri honey in the sandy coastal districts is not as a rule of such high grade quality as in heavier soils.

TUART (*E. gomphocephala* D.C.).—This eucalypt is situated mainly on the south-west limestone country around the coast extending from Busselton in the south-west to the Moore River in the north. The flowering of this species is very irregular owing to the depredation of the Borer Grub; a weevil like pest that lays eggs

Tuart.—Note the caps being pushed off prior to the opening of the flowers in the left spray.

in the buds and then drops the cluster of buds on the forest floor. This pest is responsible for the loss of tons of honey every year but is, however, attacked by a wasp parasite. When the parasite becomes strong enough to combat the pest the tree produces a good quantity of flowers the honey produced being of a pleasing flavour and when candied is very solid and fine grained. This tree is a most uncertain yielder and it may be four to seven years between flows; the buds taking two years to develop.

KARRI (*Eu. diversicolor*).—This giant of the forests is a beautiful tree with a height of up to 250 feet and a trunk of up to 100 feet before the first branches. This giant begins flowering sometimes in June and, in general, a flow continues until the next April. Six to eight months when conditions are favourable. The honey is a general favourite and in the fancy grade; being very light in colour, good density, and very white when crystalised. The buds take 18 months to two years to develop and they have a flowering cycle of approximately once in four years. The pollen sometimes is on the light side and bees working on this flow are often extremely hostile to manipulate. It is not advisable to leave hives in the karri country during the winter, particularly if they are in the shade, as the district has a heavy rainfall and a number of the hives are apt to die out during this period or early the following spring.

SALMON GUM (*E. salmonophloia* F. v M.).—This eucalypt is a very uncertain honey producer varying greatly in its flowering periods at different seasons of the year. Bud development uncertain: Honey second grade.

SWAMP YATE (*Eucalyptus occidentalis* Endl).—The honey from this variety is very choice being very mellow to the palate, light in colour and when candied a very fine grained easy spreading variety. Rather uncertain yielder as the buds are often attacked by parasites and the gathering period interrupted by wet weather as its flowering time is in April and May. Usually flowers every year.

There are a great number of other species of trees, shrubs and ground flora that have not been listed in this article. These comprise over 50 varieties of Banksia alone that bloom at different times of the year and in different districts, also the Mallees and Marlocks which also number many different varieties and blooming periods, numerous ground flora and bushes which will become familiar to apiarists, as they work and become acquainted with their own districts and the seasons of their flowering periods. As there is such a number of flowers that yield nectar it would take a large volume to list them all. The list compiled here, however, should give the new apiarist an idea in which district and timber country to inspect for future flows. The enterprising apiarist should have a rough programme of possible flowering periods mapped out about 12 months ahead and have his hives strong and ready to place on to different locations and not wait for the bees to build up on the flow as in a short blooming period half the flow will be over before the hive is strong enough to take full advantage of it.

Always remember, leave enough honey in the hives just prior to a flow cutting out. This precaution is necessary, sometimes to see the bees safely through a dearth period, or between flows, or to carry them safely through the winter. It is bad policy to extract all the honey and later on find it necessary to feed the bees to see them through a lean period.

Erratum.

In the *Journal of Agriculture,* Vol. XXII., No. 4, December, 1945, article on "Subterranean Clover Seed Production," page 364, paragraph 3, Conclusions, for "Dinoc can play an important part in the control of broad leaved weeds in onion crops. Spraying should be carried out when the weed seedlings are very small at which stage a 1:120 solution plus 2 lb. of sulphate of ammonia per gallon at 100 gallons per acre is very effective and causes negligible damage to transplanted onions," read "Dinoc can play an important part in the control of broad leaved weeds in onion crops. Spraying should be carried out when the weed seedlings are very small at which stage a 1:120 solution plus 2 lb. of sulphate of ammonia per 100 gallons at 100 gallons per acre is very effective and causes negligible damage to transplanted onions."

By Authority: WILLIAM H. WYATT, Government Printer, Perth.